Chemical Engineering Progress

MARCH 1955

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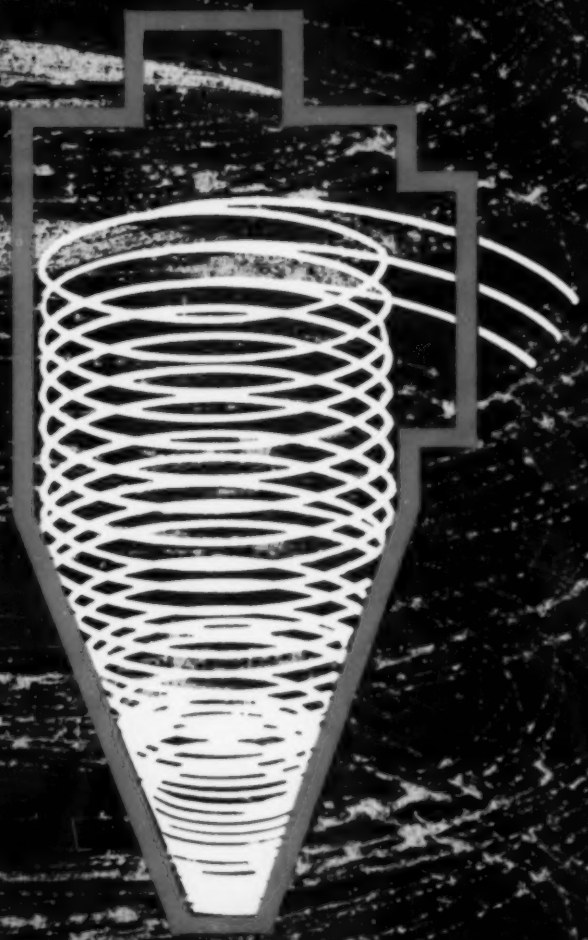
The Great Debate



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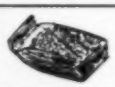
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this month's cover

Dust . . . black, swirling dust is the theme . . . Its removal by centrifugal collectors has been studied by authors Lapple & Kamack (p. 110) whose paper is one of a pair on the subject—the second by Silverman *et al* will appear next issue.

—cover by Milton Wynne Associates.

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For a brief description of each article . . . see "What's in This Issue"—page 31

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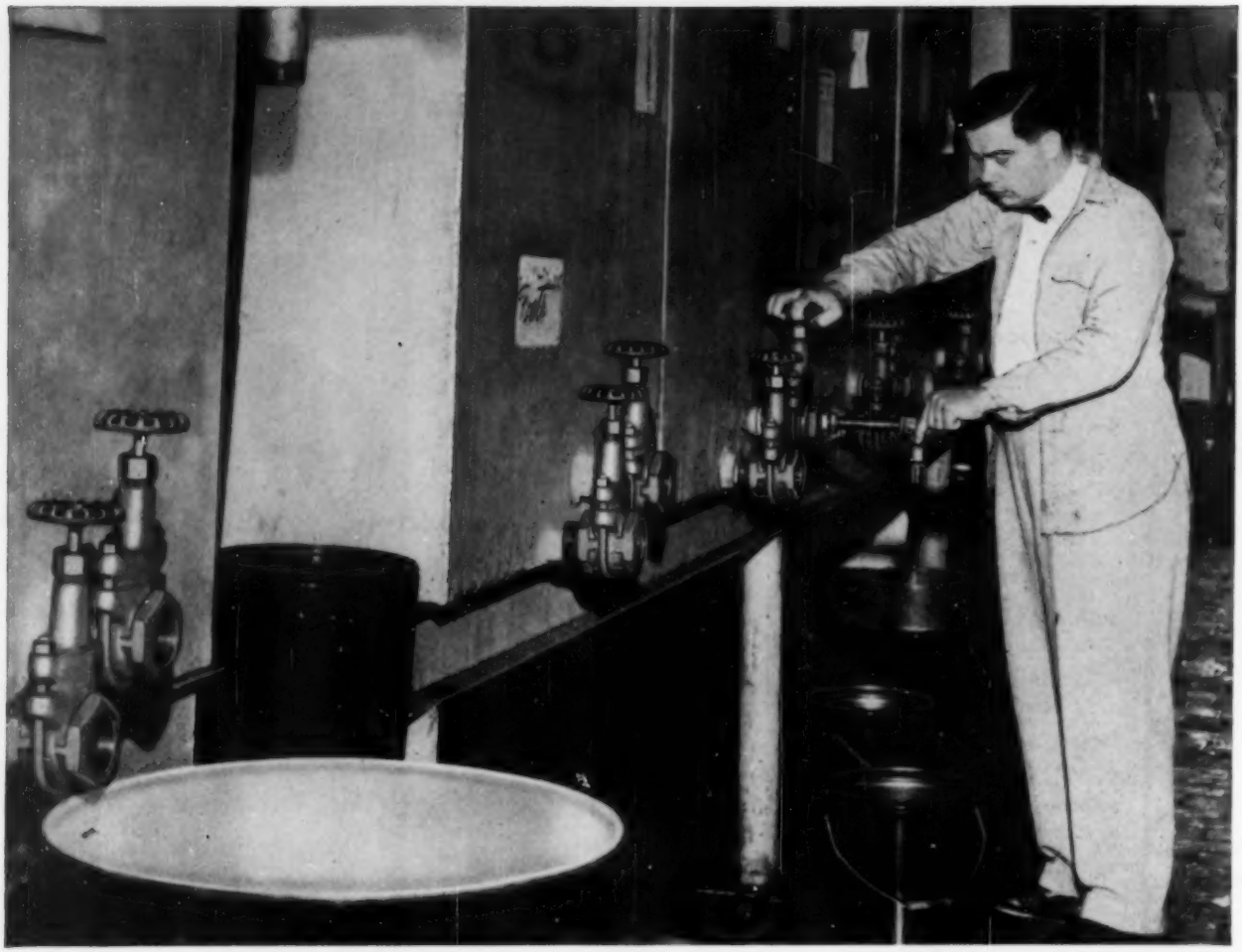

Leakage troubles here stopped by these CRANE VALVES

THE CASE HISTORY—Read why Hysan Products Co., Chicago, changed to Crane Clamp Gate Valves in all process and storage piping. Hysan makes liquid waxes, pine oil and coal tar disinfectants, liquid soaps, and similar chemical specialties.

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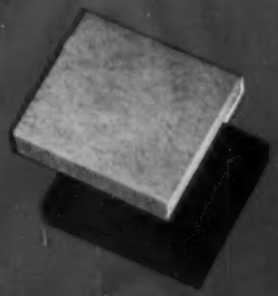

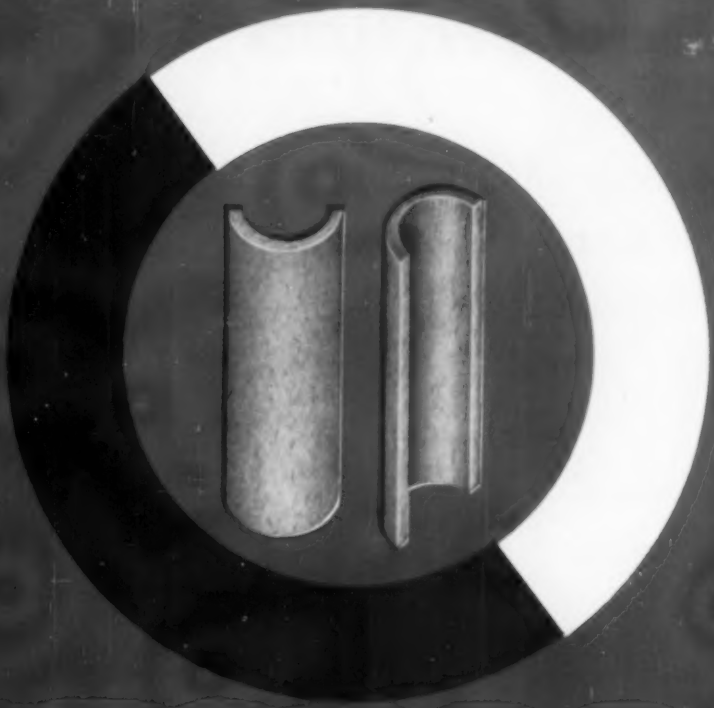

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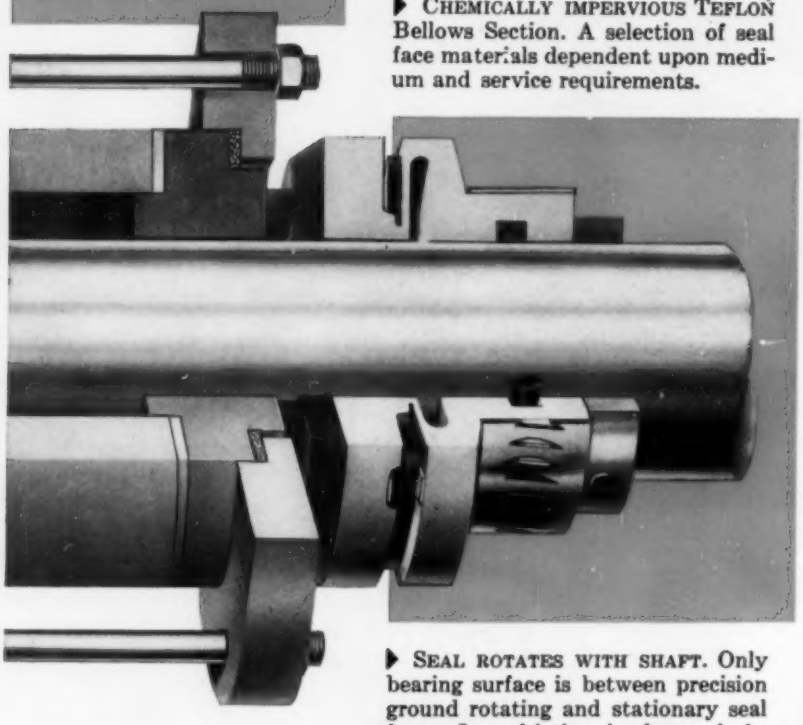

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LETTERS TO THE EDITOR

Getting Ahead–

The following five letters (except the last) were sent to Francis J. Curtis, vice-president of the Monsanto Chemical Company, St. Louis, Missouri, in recognition of his article "The First Five Years," which appeared in C.E.P. December, 1954, page 590. He kindly sent these on to this office. ——Editor.

As an "ex-chemist" now doing strictly administrative work in personnel and public relations, I am often told that my chemical training and experience have gone to waste. I have a hard time convincing people that I am putting all of my experience and training to excellent use. I can also appreciate the problems of the chemists and chemistry much better than a "lay" administrator.

SHEPHERD STIGMAN

New York

After five years at Nitro and five years' Naval Service in Chemicals and Explosives, I joined the Tacoma Chamber of Commerce as a consulting engineer in an effort to "broaden industrial thinking," taking advantage of engineering mental training, which, as you stated, is excellent mental training for anything.

I believe that such thoughts as expressed . . . contribute greatly to assisting the younger engineers in their scientific fields.

MARSHALL T. RAMSTAD

Tacoma, Washington

"The First Five Years" certainly brings out points we can all well profit by, and I hope that . . . can put some of your suggestions into practice.

EDWIN COX

Richmond, Virginia

After reading your article . . . I felt that I must write you . . . It was most interesting . . . undoubtedly the most lucid analysis of the problems facing the young graduate engineer of today.

Since I graduate with a B.S. in chemical engineering this June, the problems which you discuss were quite apropos. With the numerous employment opportunities which face today's Ch.E. graduate, it is easy for one to lose sight of the basic purpose of his technical training—the utilization of his education for the further development

(*Continued on page* 12)

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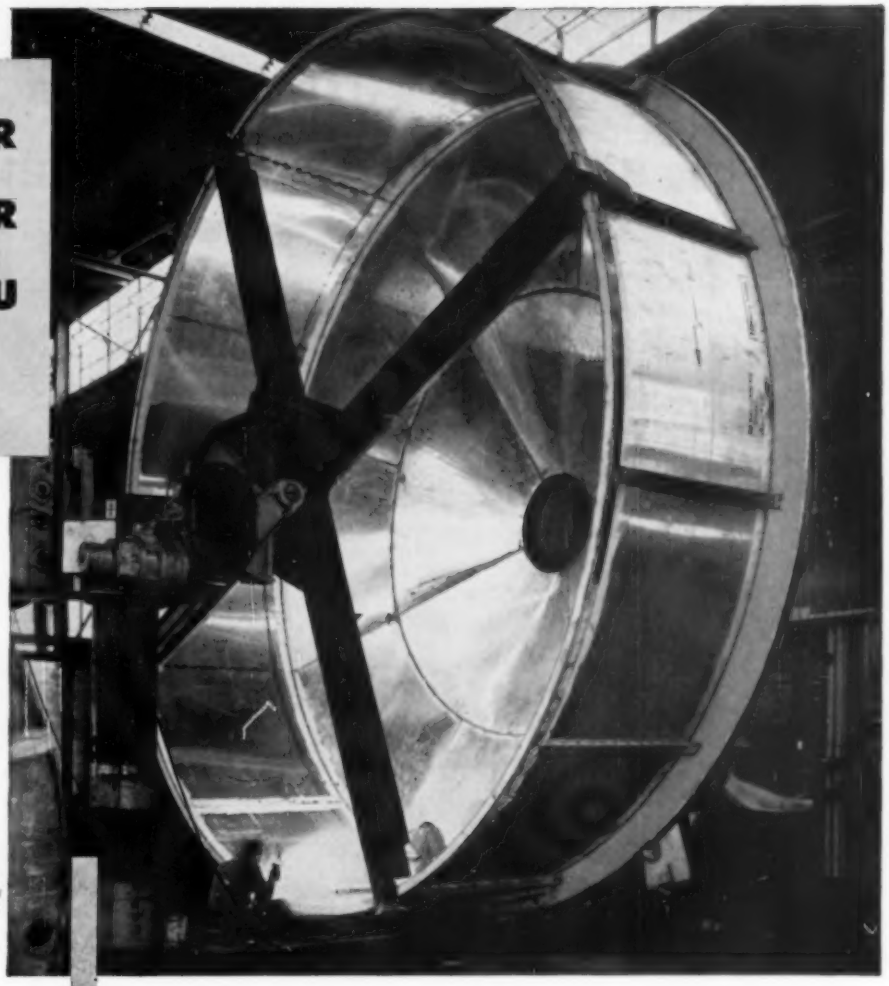

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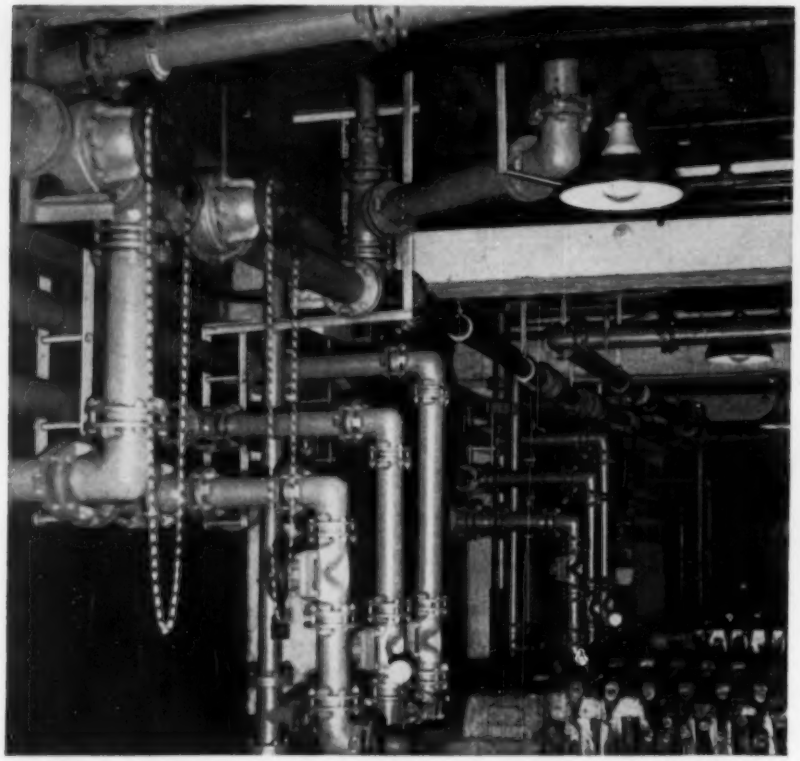
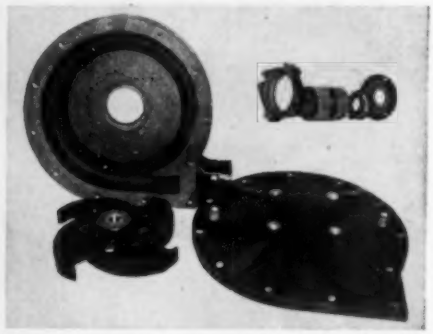


A typical large installation of Haveg pipe, valves and fittings showing simple method of support required. Haveg pipe is unaffected by thermal shock, seldom requires insulation.



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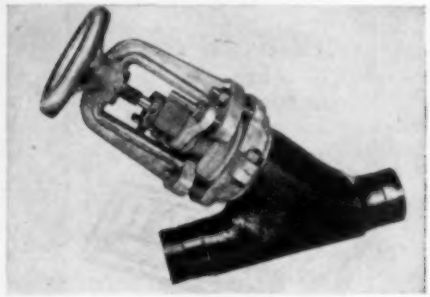

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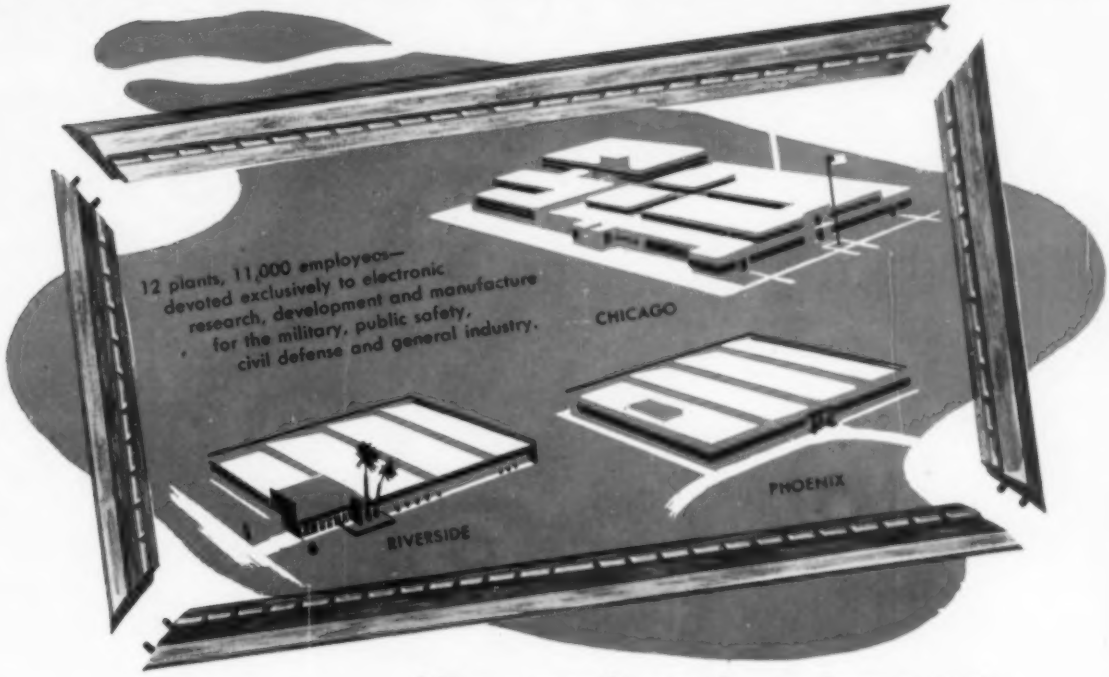

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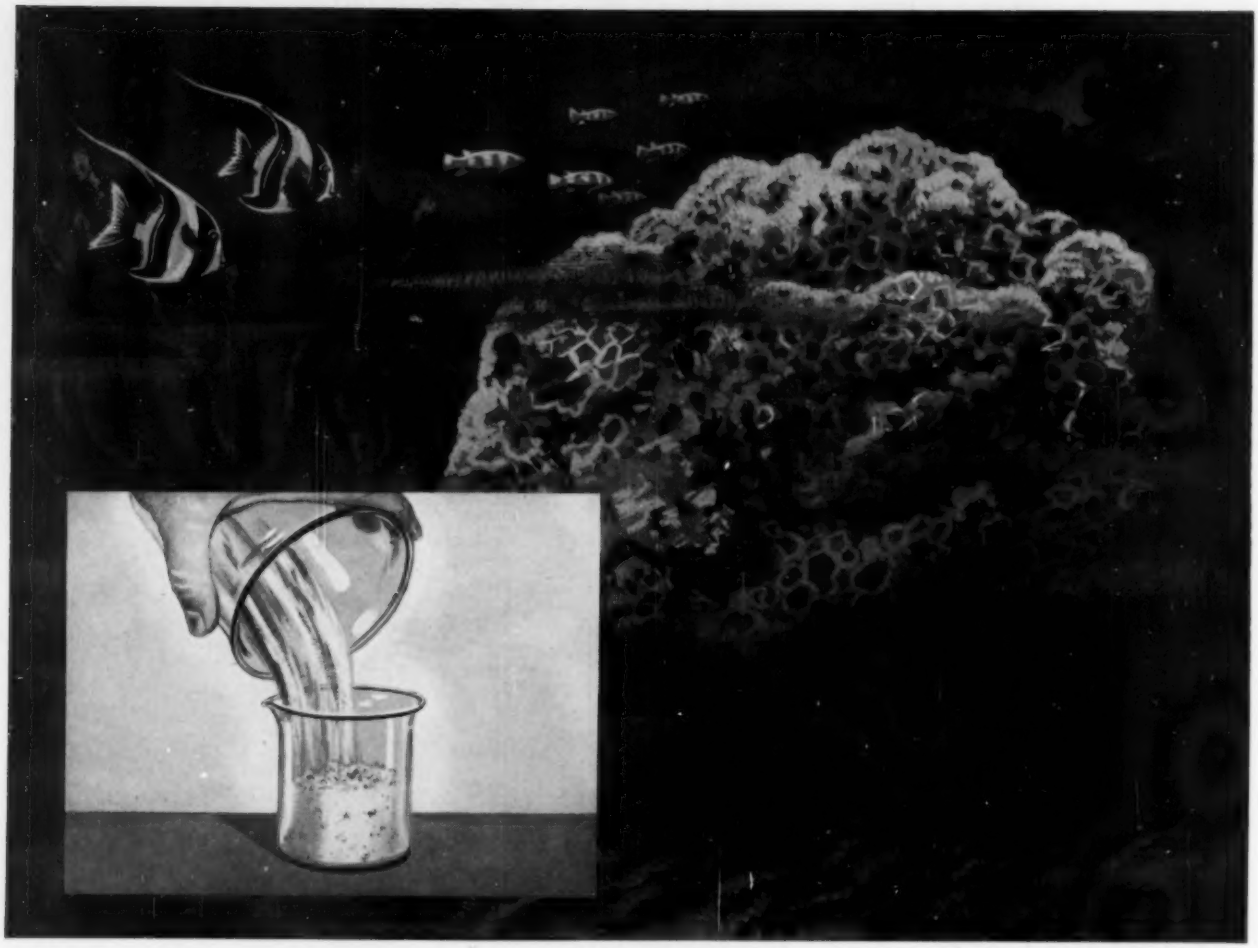

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LETTERS TO THE EDITOR

(Continued from page 6)

of his profession. Many of the positions which I have been offered, with most attractive salaries, seem to utilize my engineering training only in a very general way. In fact, many jobs would easily be filled by non-technical personnel, but, due to company policy, an engineer is required for the position.

I certainly appreciated the opportunity to read your enlightened discussion . . .

PAUL C. ELLIOTT

Terre Haute, Ind.

A man's job is important but it is only one aspect of his life. Where he lives, how much he earns, and how well a company delivers on its promises are significant. Many company spokesmen seem to belittle these aspirations as "boyishness." On the contrary, they are evidence that the young men of today like young men of other days, are groping for a "better" life. Today the area of choice is wider and the confusion may, therefore, be greater. The confusion is compounded by a tense international situation and by the growing suppression of individuality that is a necessary adjunct of working in large companies; playing, worshipping, and learning in institutional groups; and living in "Levittowns."

People, today, want something better. They have been reared to great expectations. Let us hope that many will hold on to their dreams and keep up the struggle. Progress may result if they do. Progress certainly won't result if they don't.

A. NELSON

Fort Lee, New Jersey

Books on Engineering Wanted

At the time of my visit [writer refers to a recent visit to Buenos Aires, Argentina] plans were under way to expand the existing library facilities [Argentine-American Cultural Institute] and they are particularly anxious to increase their stock of engineering books, which appear to be in heavy demand. In this connection, I was asked whether any assistance could be expected from the U. S. in the form of second-hand book donations. I promised to look into this matter, which is the reason for this letter. In case you have on hand any chemical, metallurgical, civil, mechanical, sanitary, or electrical engineering text books, which have recently been replaced, this would form an excellent outlet for such surplus books and they may be sent to Mr. Luis Fiore, President
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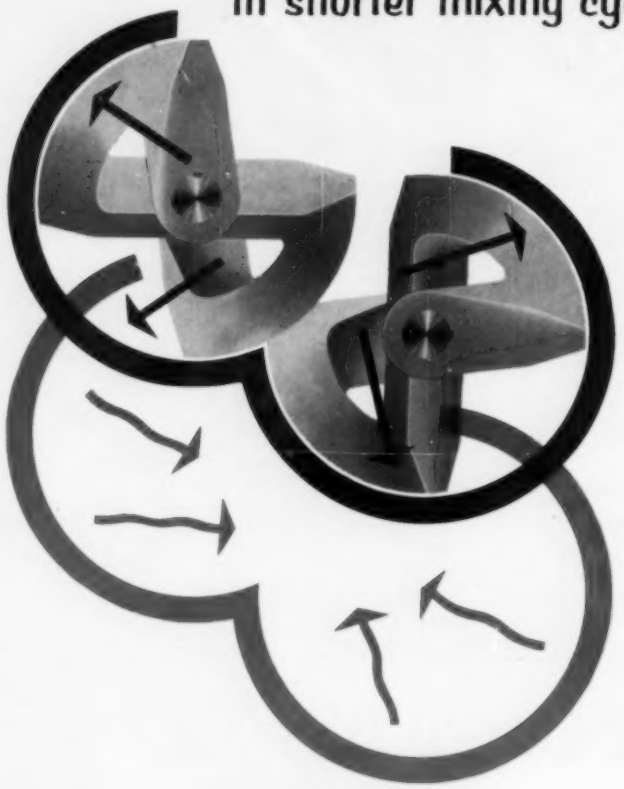
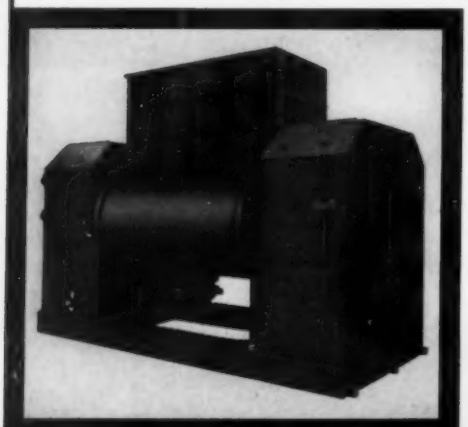
From this unique bowl
...COMPLETE DISPERSION
...MAXIMUM HEAT TRANSFER
in shorter mixing cycle





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The unique shape of this mixer bowl presents a greater ratio of heated surface to the mix. Close clearances between the mixer arms and shell eliminate build-up of materials, facilitating heat transfer.

Overlapping sigma-arm mixing action exposes new surfaces and breaks down the entire mass with each rotation, eliminating peak loads and producing a homogenous mix in a short mixing cycle.

Available in capacities up to 750 gallons.

BAKERY-CHEMICAL DIVISION, York, Pennsylvania

NOTED AND QUOTED

The Engineer and Creativeness

. . . the profession of engineering requires the same elements of education as all other professions, but with greater emphasis upon creativeness. The highest professional education in engineering will weld art or practice with basic science in an approach so fundamental that it will level the walls of narrow professional specialization which have been raised primarily by the pride of craftsmanship. The key to professional education is stimulation of the desire to learn beyond the classroom and the college. This demands the acceptance of responsibility by the student, while in college, for much of his own education through willingness to attempt the solution of new problems. Through such experiences provided under the guidance of those who have themselves carried responsibility, the student will sense his coming accountability for operating in the framework of society for the general good and in the highest tradition of his professional group.

L. E. Grinter,
"Education for a Creative Professional Life"
A.S.E.E. Meeting

Again the Engineer!

The engineer, because of his technical knowledge and his ability to comprehend the problems and effects of enemy attack, must consider himself a key man in formulating, selling, and carrying out civil defense plans.

Val Peterson
in *American Engineer*

Pipeline Needed

. . . In the case of full mobilization, we will need a petroleum pipeline from the gulf coast to the New York-Newark area, with a capacity of 500,000 barrels per day, with an additional line from Lima, Ohio, to the east coast of 450,000 barrels per day.

Victor A. Cooley
in *Stanford Research Institute Bulletin*

The "Unknown" in Nuclear Science

Nuclear science embodies a new realm of physics, the potentialities of which we cannot fathom at this time. There are, of course, the obvious applications of the heat of nuclear fission and fusion for the generation of power. But quite apart from this application, it seems amply

(*Continued on page* 18)

it's new!

VANTON'S EXTERNAL BEARING

X-B PUMP

without stuffing box, gaskets or valves

The Vanton corrosion resistant "flex-i-liner" self priming rotary type plastic pump is available in a new design that permanently protects all bearings from fumes or chemical attack.

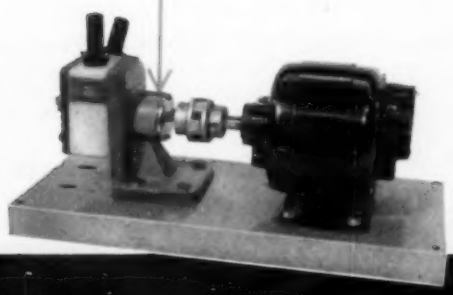
Low maintenance is assured since shaft bearings are external and the rotor assembly is stainless steel. The only wearing part is the quickly replaceable low cost flexible liner.

Capacities range from fractional to 5 gpm with 0-50 psi discharge pressures . . . Vanton XB will develop vacuum up to 26" Hg. and will handle corrosive liquids, gases, viscous fluids or abrasive slurries.

The unique design of the XB isolates the fluid from all actuating mechanisms or rotating parts. Pumping is accomplished by a rotor mounted on an eccentric shaft, creating a squeegee action on the fluid. Displacement is positive and non-agitating.

Wide selection of body block and liner materials makes Vanton XB suitable for an endless list of chemicals, pharmaceuticals and food products. Body blocks are available in: Bakelite, polyethylene, Lucite, Buna N, PVC, and stainless steel. Flexible liners are available in natural rubber, pure gum rubber, neoprene, Buna N, hycar, hypalon and silicone.

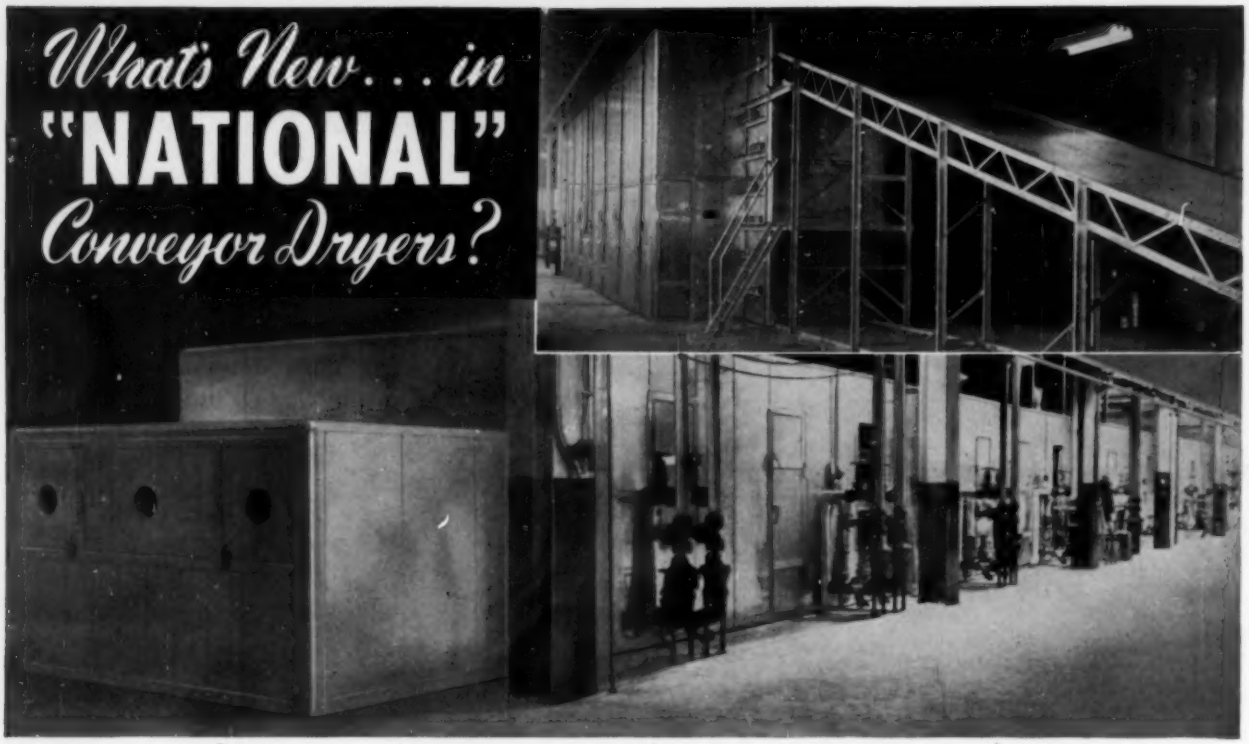
it's here



VANTON PUMP & EQUIPMENT CORP.

Division of Cooper Alloy Corporation • HILLSIDE, N. J.

What's New . . . in "NATIONAL" *Conveyor Dryers?*



Two "National" Conveyor Dryers are illustrated above: Upper, a large Multiple-Unit, Multiple Apron dryer; lower, a fourteen-section Multiple-Unit, Single Apron Machine.

NEW "P-4" CONSTRUCTION

"P-4" Construction means a precision-built, pre-fabricated, truss-type structure, providing a new measure of strength, rigidity and durability. Advantages to the customer are obvious: Longer service life for the Dryer; smoother operation; freer access for cleaning and maintenance; and reduction of installation time in the customer's plant of as much as 50%. Another important feature of "P-4" Truss Type Construction is that the special method of attaching the panels meets all Underwriter's Codes covering explosion hazards.

IMPROVED HOUSING PANELS

The new insulated panels (Patented and Patents Pending) used for the housing are larger, stronger, more rigid, and, with their 4" insulation, provide greater protection against heat loss. They are of trussed-and-tensioned, non-through-metal construction and incorporate expansion-contraction compensation.

IMPROVED AIR DISTRIBUTION AND CONTROL

The exceptionally high drying speed of "NATIONAL" Dryers results from a combination of adjustable fan power and a unique air distribution system, controlled to assure equal volume of air to the entire run. There is no "shading"—no uneven drying. This arrangement permits drying at consistently higher speeds than those previously permissible. Patented Indexing Orifices, Turning Vanes and other devices and arrangements assure unequalled versatility and precision in air distribution and control.

SUPER-POWER FANS

"NATIONAL" has developed the adjustable-pitch principle into its axial-flow fans which provides far greater operating potentials than heretofore used in any drying machinery. Greater speeds and volume of air can now be employed and adjusted to the specific requirements of the drying operation. The new fan construction includes special alloyed metals fabricated by an improved welding technique. The Fan mountings, insulation and lubricating systems have also been redesigned to provide improved smoothness of operation and virtually no maintenance.

• • •

Other features of "NATIONAL" Conveyor Dryers include continuous hopper feeds; automatic leveler to conveyor belt; pressure extraction and heating for pre-drying.

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TYGON "ATD" Hot Spray PAINT

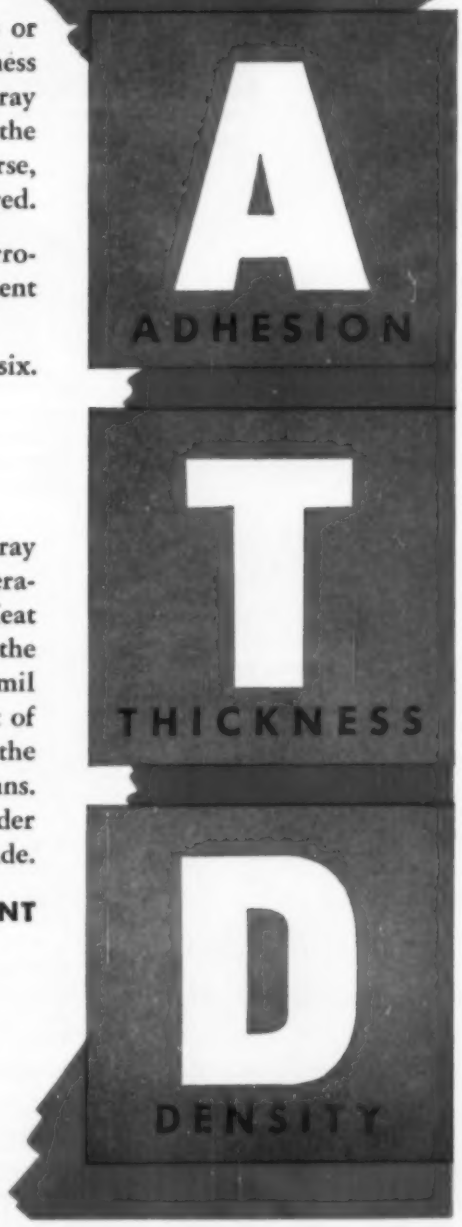
Tygon "ATD" Hot Spray Paint builds a film thickness of 3 mils or more at a single pass—5 mils or more in two coats—a film thickness that would require six or more coats of conventional cold spray vinyl paints. Adhesion is better. Film continuity (because of the thicker and denser film) is immeasurably improved. And, of course, the proven corrosion-resistance of Tygon Paint is in no way impaired.

Tygon "ATD" Hot Spray Paint offers the maintenance man and corrosion engineer a lower cost, surer way to protect plant and equipment against corrosive attack.

Lower cost— because two coats will do the job of five or six.
Lower cost— because no thinning is required.
Lower cost— because of less overspray.

HERE'S HOW IT WORKS—

Tygon "ATD" Hot Spray Paint is heated in a conventional hot spray heater to a temperature of approximately 160°F. At this temperature, the viscous Tygon "ATD" Hot Spray Paint becomes fluid. Heat does the work of thinners. As the hot paint leaves the gun, the solvents in the paint evaporate, and a high solids content, 3 mil thick protective coating is deposited on the target. Because most of the solvent has evaporated before the paint hits the target, the coating dries quickly. The finish is excellent, without sags or runs. The film is dense, free from pin holes, and resistant to a wider range of corrosives than any conventional protective coating made.



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Write today for free literature and detailed information how you can use this lower cost, safer, and better "ATD" way to cut your corrosion losses. Address Dept. CEP-355.

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In all our processing equipment—standard or special or made to order—we focus the knowledge and experience of our engineers on the design details and end use. We feel that this engineering service is an essential part of our manufacturing service which covers a wide range of processing equipment, particularly in the fields of distillation, absorption, crystallization, solvent recovery and purification, extraction and similar operations.

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NOTED AND QUOTED

(*Continued from page* 14)

evident that here is a tremendously fundamental field of physics with great unknown potentialities awaiting exploitation. We have regarded it as essential for students to understand such concepts as heat, light, optics, and sound. Is it not reasonable that students also should have a knowledge of fundamental concepts of nuclear processes, including the transmutation of elements, the radiation phenomena associated with nuclear reactions, the fundamental processes involved in nuclear fission and fusion, and other significant aspects?

Arthur Bronwell
"Basic Conflicts in Engineering Education" at A.S.M.E. meeting

MARGINAL NOTES

Minerals for the Chemical and Allied Industries. Sydney J. Johnstone. John Wiley & Sons, Inc., New York (1954), 692 pages, $11.50.

Reviewed by N. Morash, Supervisor, Development & Engineering Dept., Titanium Division, National Lead Co., Sayreville, N. J.

Mr. Johnstone states in the first paragraph of the preface that "The Object of this book is to present in a concise form essential information on the properties of these minerals and metals, their sources of supply, processing and metallurgy, and uses with special references to specifications laid down for their uses in particular industries." The author has done well in keeping the book within these specified boundaries. He has succeeded in compiling in this book a remarkable list of specifications for the various minerals, metals, and products mentioned therein. This collection of specifications is undoubtedly the strongest point in the book. The availability of these specifications should be of considerable help to those interested in obtaining such information.

The book also goes into detail with regard to the steps required to process the various minerals into their usable forms. In addition to this, ultimate uses for these various products are discussed. It is our opinion that this portion of the book hould serve as a good primary reference for those interested in market development in these fields and for students trying to obtain an over-all view of the industry. It is thought too that the book would have been of greater value to the student if it had contained

also flow sheets of the processes discussed and pictures of some of the operations.

The bibliographies given in the book provide good secondary references.

The material presented in the book is well written and easily readable.

Atomic and Free Radical Reactions. E. W. R. Steacie. A.C.S. Monograph Series No. 125. Second Edition, Vol. 1-2, Reinhold Publishing Corporation, New York (1954), 900 pages, $28.00.

Reviewed by Edgar L. Piret, University of Minnesota, Minneapolis, Minn.

This authoritative monograph assembles and critically discusses the mass of often contradictory information available on the rates of elementary organic reactions. The term elementary reaction is used to denote the individual stages of simple order which together make up the observed over-all reaction rate. Highly reactive atoms, free radicals, and other substances of transitory nature are now well established as being important in determining the mechanism of many thermal and most photochemical reactions.

The reaction systems included are those containing carbon and hydrogen, oxygen, nitrogen, chlorine and fluorine, bromine, iodine, sodium, other metals, or sulfur. A general discussion is given of experimental methods.

The author's presentation is clear, and his style almost conversational, so that it is enjoyable to read and also worth while to study for its scientific value.

Chemical engineers interested in reaction kinetics will find this book to be advantageous in following the more recent laboratory researches in this area.

Phénomènes de Fluidisation by P. Reboux, Association Francaise de Fluidisation (1954), 165 pages, 1800 francs.

Reviewed by Edgar L. Piret, University of Minnesota, Minneapolis.

This well-organized survey of the mechanism of fluidization is one result of the work of a task group organized by sixteen French chemical and process companies. The group cooperated to assemble, analyze, and make available to the companies as useful as possible a digest of the present-day published information in the above field. As part of the program, basic research studies in selected areas have also been initiated in four member laboratories.

The presentation is as quantitative as the field permits, with many solved numerical problems, and drawings being used to illustrate the points made. The many large-scale charts and nomograms

(*Continued on page 22*)

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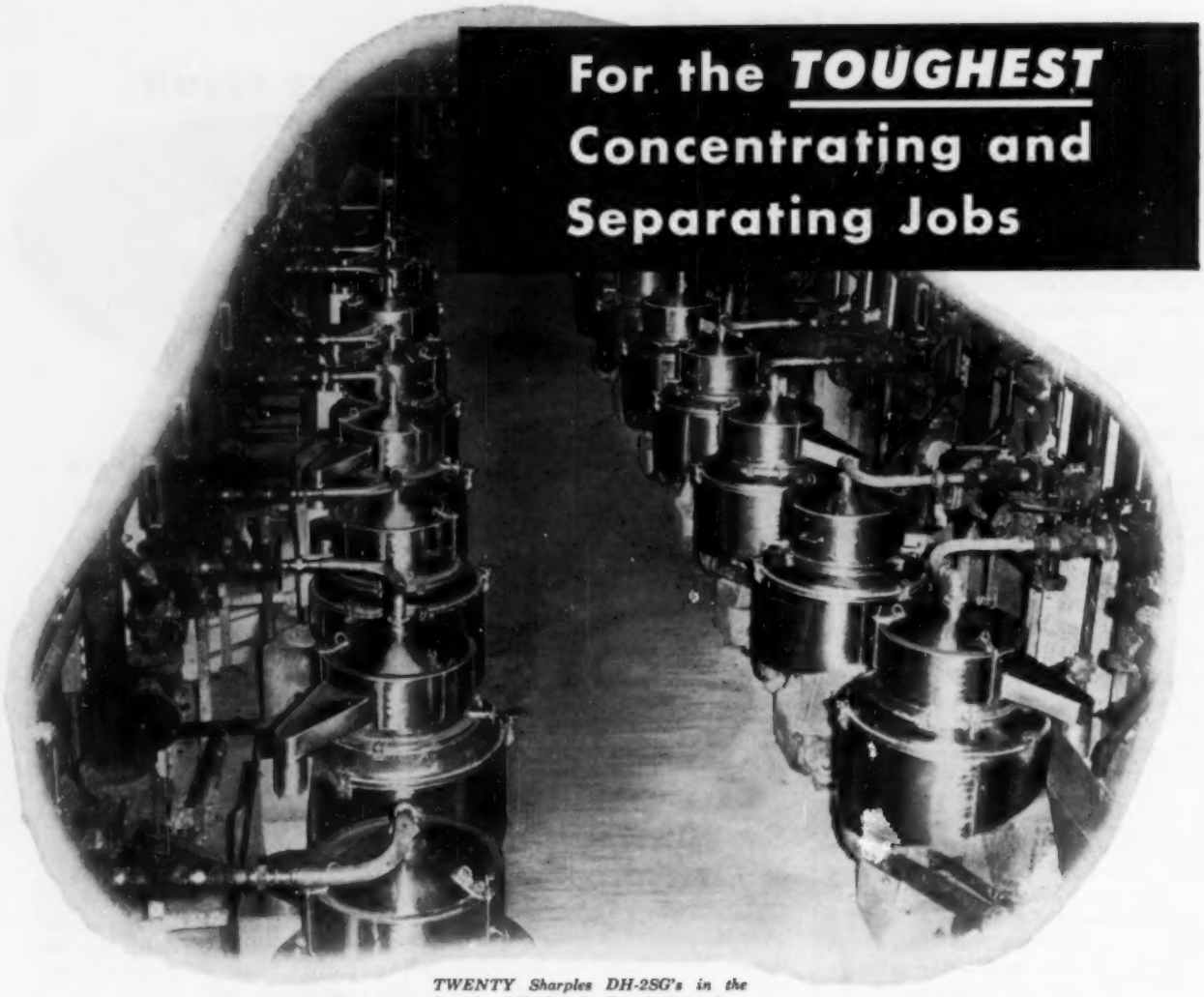

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This new Heavy Duty Nozljector is capable of handling loads up to 40 HP input without power loss or motor strain . . . because of the exclusive massive parallel drive . . . covers of this continuous nozzle centrifuge are capable of handling up to 175 gallons/minute . . . nozzles and bushings are made to take long hard service . . . construction is sanitary and easy to clean.

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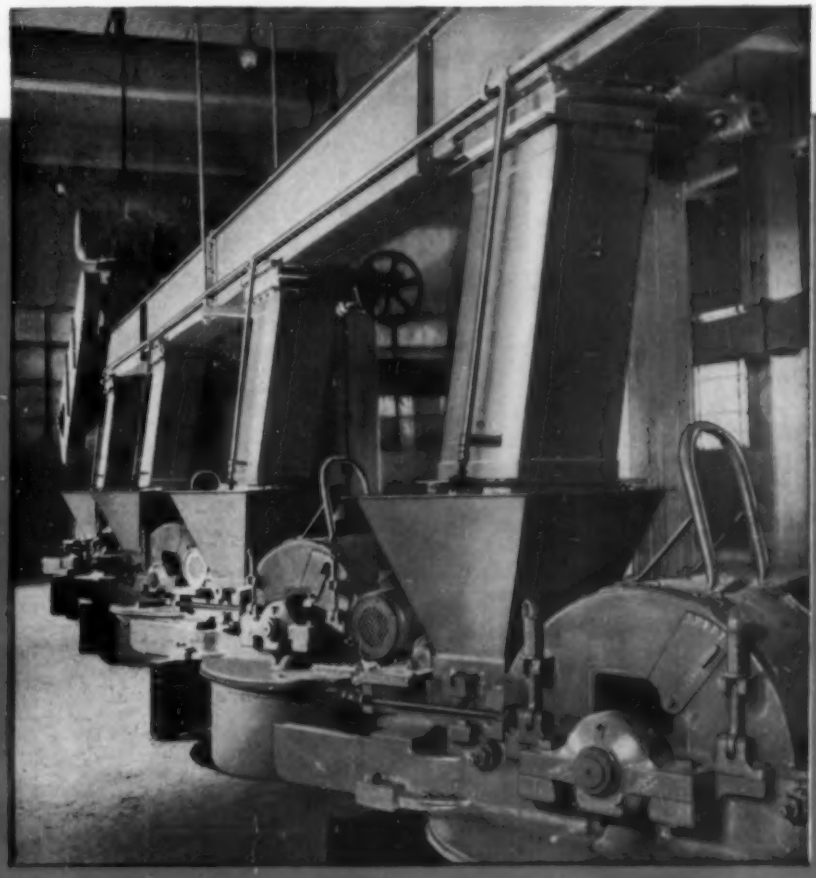
Viva Mikro-D! It Helped Mexico Make More and Better Tortillas!



New World Way

Section of a battery of MIKRO-D PULVERIZERS grinding tortilla flour in a plant in the suburbs of Mexico City.

(Photo by Mary St. Albans)

Old World Way

There's a revolution going on south of the border . . . a peaceful one . . . and we are proud to have supplied the "heavy munitions".

For centuries the corn meal for tortillas, the substitute for bread in our sister republic, was ground in the village mill or by the housewife with her own crude implements. Today it is mass produced in better quality, and Mexican folks are enjoying the obvious benefits of modern food engineering.

One plant alone in the suburbs of Mexico City is turning out a minimum of 600,000 pounds of corn meal per day by a patented process. And every ounce of it is ground and blended in a battery of 19 MIKRO-D PULVERIZERS.

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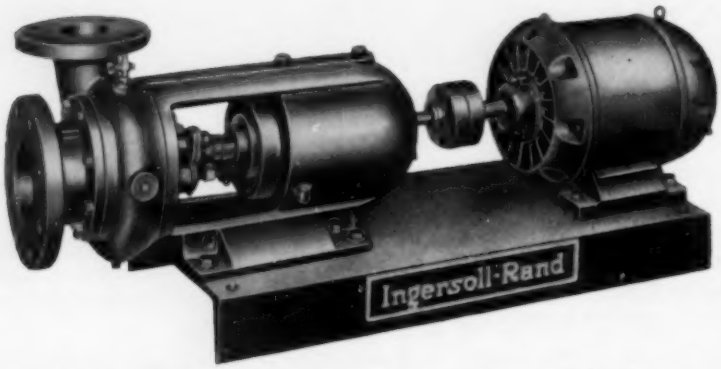

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MARGINAL NOTES

(*Continued from page* 19)

facilitate calculation and will make the book a convenient reference. The subjects covered include the conditions required for the initiation of fluidization; the density, viscosity, and flow properties of fluidized beds, and their transport, erosion, and heat transfer properties. Specific industrial applications are treated only briefly, the emphasis being placed on presenting in an abbreviated manner the more quantitative data and theories of the field.

As we expect of a work in the French language, the presentation is unambiguous and lucid. The modern American and European literature has been canvassed by the writer and use is made of some European reports, which are largely inaccessible to American readers. The author is to be complimented on having well fulfilled his task.

The Beginnings and End-Uses of Wood

Wood Chemistry, 2nd Edition, Vol. I. Edited by Louis E. Wise and Edwin C. Jahn. Reinhold Publishing Corp., New York (1952), 730 pp. $15.00.

Reviewed by John B. Calkin, Chemical Consultant, New York.

Volume I is divided into three parts dealing with the growth, anatomy, and physical properties of wood, components and chemistry of the cell wall, and the extraneous substances.

The origin and anatomy of wood and its mechanical and physical properties are covered in the first part of the book.

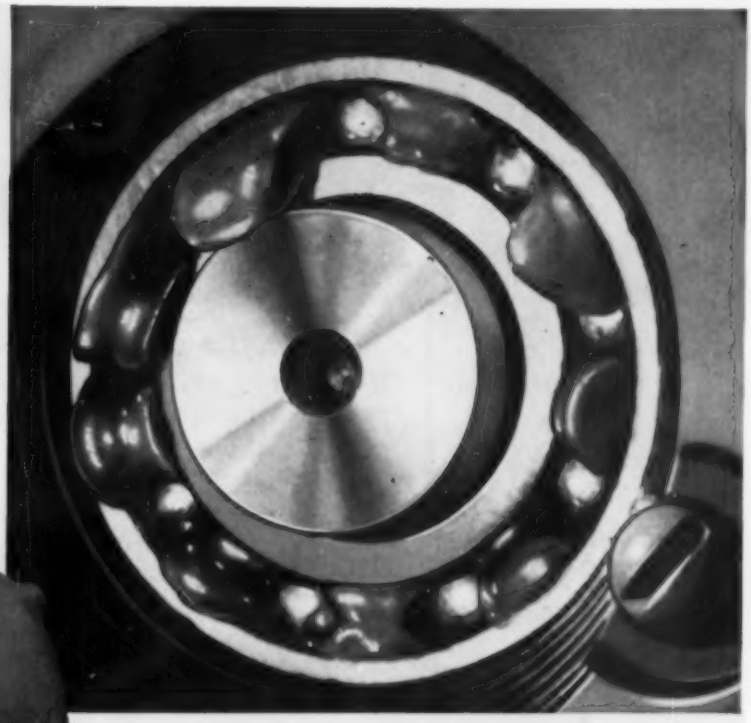
The second part discusses the chemistry of the cell walls of wood, the chemical and physical evidences regarding the constitution of cellulose, chemically modified cellulose, solvents for and solutions of cellulose, cellulose compounds and derivatives, hemicelluloses and the chemistry of lignin.

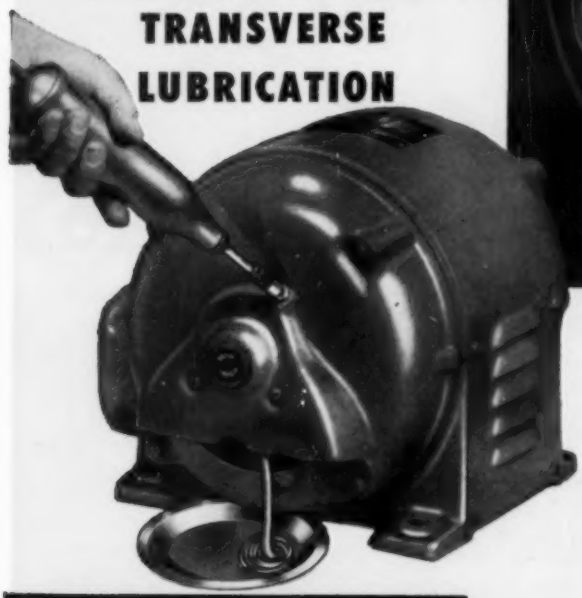
Extraneous substances are grouped as the volatile oils, wood resins, tannins and coloring matters, and miscellaneous components. There is a chapter dealing with the relation of taxonomy to phenolic and other extraneous components of coniferous heartwoods.

The editors did an excellent work in the selection of chapters, authors, and in bringing forth a readable, coordinated, ready reference work in the field of wood chemistry.

This A.C.S. Monograph is recommended highly and should be studied, perused, or referred to as particular needs may dictate. Volume II was reviewed previously.

Motor life vastly increased with U. S. MOTOR TRANSVERSE LUBRICATION





See how it works. The above cut-open view shows how grease extrudes through the bearing transversely when grease gun is applied, forcing old grease out and replacing with fresh new lubricant. Lubriflush is an exclusive U. S. Motors system, proved by 20 years' application.

U. S. MOTORS

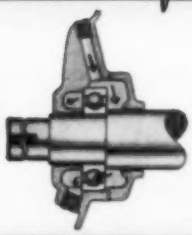
Lubriflush

THE ONLY SYSTEM OF COMPLETE RE-LUBRICATION

without disassembly of motor!

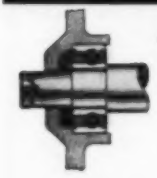
Motor bearing failure is costly. Bearing life is limited to the life of its lubricant. Therefore re-lubrication is a *must*. But to completely re-lubricate any ordinary bearing you have to open up the motor. That costs money – in man-hours and down-time. *The solution* – Install U. S. Motors. Just apply a grease gun once a year. The injected grease is applied *behind* the bearing and is forced transversely through the bearing, ejecting all the old grease out the drain. How simple. How quick. How economical.

Lubriflush BEARING



See how the lubricant is applied behind the bearing. It has to go THROUGH the bearing. No dead areas. Largest grease volume surrounds bearings—up to 12 times more than ordinary types.

ORDINARY BEARINGS



CARTRIDGE TYPE

Limited in volume of grease. When grease fails, bearing must be replaced.

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a National Engineering Center?

A C.E.P. interview with Chalmer G. Kirkbride, A.I.Ch.E.-Representative Member, Committee of Five Presidents, on the problems involved in joining with four other societies and selecting a suitable site.

Q. Mr. Kirkbride, does the resolution of the Committee of Five Presidents recommending Pittsburgh as a site for the new Engineering Center mean the engineering societies are now ready to join together and move to that city?

A. No.

Q. What then will be the next step taken, to decide the issue?

A. The Committee of Five Presidents was set up to study and recommend a satisfactory location for an engineering center. This Committee has made its report, recommending Pittsburgh on the basis of proposals from the various cities up to a February 1st deadline. It is now up to the governing boards of the five societies to either (1) accept the recommendation, (2) refer it back to the Committee, or (3) take some other action.

Q. What cities were considered?

A. New York, Philadelphia, Pittsburgh and Chicago. Ruled out earlier was Washington, D. C.

Q. Why?

A. It was decided by the Committee that Washington, D. C. would not be the best place for an engineering center—without regard for a specific site. In other words, the center of our Government is all right for many organizations, but could be distracting to the objectives of an engineering center.

Q. What else came out of the Committee's study?

A. I would say that the most important conclusions to come out of the study were that: (1) the engineering center should be a building of about 200,000 square feet, and (2) that from the standpoint of location, New York, Philadelphia, Pittsburgh or Chicago would be satisfactory.

Q. What was the basis for the founding of the Committee of Five Presidents?

A. Elgin Robertson, then president of the A.I.E.E. called a meeting of the boards of directors of the five societies—which marked the first time a formal offer had been tendered the A.I.Ch.E. to join up with the A.I.E.E., A.S.M.E., A.S.C.E. and A.I.M.M.E. This meeting took place in Chicago on April 6, 1954. One of the outcomes of this was to appoint the Committee of Five Presidents to make the study.

Q. Where does the United Engineering Trustees (U.E.T.) fit into this pattern?

A. The U.E.T. is a corporation which owns and manages the Engineers' Building on West 39th Street in New York City—present home of the four engineering societies. U.E.T. is owned equally, one-fourth by A.S.M.E., and so on. Each society has three directors on U.E.T.'s board and it is operated as a joint enterprise, but the board of directors of U.E.T. runs its affairs.

Q. Does the U.E.T. have any responsibility for these relocation considerations?

A. U.E.T. evidently feels it should have some say, but this is entirely in error because A.I.Ch.E. has no equity in U.E.T. Therefore, U.E.T. cannot represent the *five* societies—only four.

Q. Should the A.I.Ch.E. purchase an equity in U.E.T.?

A. I think it would be a serious error for the A.I.Ch.E. to do so. By that I mean, the amount of money we would have to pay to match the equity that each of the four other societies has in U.E.T. would be based, to a certain degree, on appraisal.

(*Continued on page* 26)

To the Governing Boards of: A.S.C.E., A.I.M.M.E., A.S.M.E., A.I.E.E., A.I.Ch.E.

After extended study and careful consideration of all the data made available to us as of January 31, 1955, regarding proposed location in New York, Philadelphia, Pittsburgh and Chicago, we offer the following:

In considering the New York proposed Columbus Circle site, the Committee felt that this was not an acceptable location. We, therefore, gave careful consideration to a preferred site generally defined as being in the Grand Central area. In like manner we considered the Illinois Institute of Technology site as not being acceptable and gave careful consideration to a preferred site in the Chicago Loop area.

Based on the lowest capital cost and lowest annual expenditure, we recommend that the headquarters of the engineering societies be located on one of the sites in the city of Pittsburgh.

We further recommend that the four founder societies liquidate the United Engineering Trustees and join with the American Institute of Chemical Engineers in the formation of a new corporation, to build, operate and maintain the new engineering center.

We consider that this concludes the assignment given us and we, therefore, consider that the Committee of Five Presidents is hereby discharged.

Respectfully submitted,

Lewis K. Sillcox, A.S.M.E.

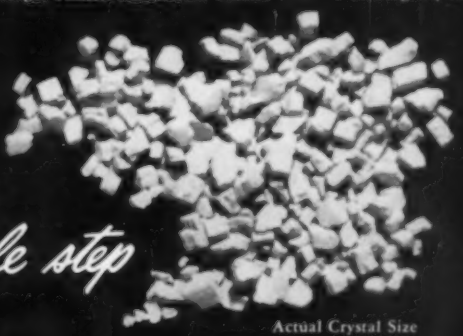
Elgin B. Robertson, A.I.E.E. Chairman

Leo F. Reinartz, A.I.M.E.

Chalmer G. Kirkbride, A.I.Ch.E.

Note the compactness of Commercial Solvents Corporation's new 225-ton-per-day Stengel Process Ammonium Nitrate Plant at Sterlington, La.

Crystalline
AMMONIUM NITRATE FERTILIZER
in one simple step
THROUGH C & I



Actual Crystal Size

C & I can now license the new CSC Stengel Process to users and furnish complete plants to produce crystalline ammonium nitrate (33.5% N). Due to simplicity of design, capital and operating costs of these plants are substantially less than similar plants using prilling and granulating processes.

FREE FLOWING In this process, ammonium nitrate of any desired particle size can be produced in a single step. Actual spreading tests in the field have proved that this crystalline ammonium nitrate is completely free flowing with a more controllable flow than competitive products.

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C & I ammonium nitrate plants using the Stengel Process can also produce limed ammonium nitrate (20.5% N) and ammonium nitrate sulfate (26.5% N). These plants are constructed at a fixed price with production and efficiencies guaranteed.

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Specialists in **CI** *Processing Ammonia*

THE CHEMICAL AND INDUSTRIAL CORP.
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ENGINEERING CENTER?

(*Continued from page 24*)

Q. What, then, do you think should be done about U.E.T.?

A. That is a problem for the other four societies. I believe a new corporation to include the A.I.Ch.E. should be set up, with each engineering society putting its money on the line in equal proportion. This would simplify the matter of valuation of shares. because the only thing going on-the-line would be dollars.

Q. Might the five societies be given enough land and money so that the only expense they would have to stand would be that of moving?

A. There is no indication that will happen. There would still, however, be the problem of the assets of the other societies. The other four representatives on the Committee have continually spoken of the $2 million they have in assets. This is predicated on certain evaluations of physical properties, plus a little over $1 million they have in a sinking fund. It still remains to be seen whether they can get another $1 million out of the physical facilities.

Q. How would this $2 million asset affect the A.I.Ch.E.?

A. It means that to set up a new jointly owned corporation, the A.I.Ch.E. would have to put up an equal share, which would be $500,000.

Q. Do we have that much money?

A. No.

Q. How would the A.I.Ch.E. obtain it?

A. This remains to be worked out. Probably through subscriptions from the membership and from the chemical industry.

Q. Did the other engineering societies get their financial "start" in this way?

A. Yes. Andrew Carnegie gave the Engineering Building on West 39th Street in New York to the so-called Founders Society.

Q. Are we apt to have such an "angel"?

A. I think the A.I.Ch.E. will have to go out and find its own contributors.

Q. How much might be asked from members?

A. I think we could probably get as much as $10 per member. The balance, or about $350,000 would have to come from the chemical industry.

Q. What are some of the outstanding benefits to be expected from an engineering center housing the five societies?

A. We have many endeavors in common. Engineers Joint Council is one of these. I think one of the greatest benefits would be in taking a large step toward ultimate unification of the engineering profession into a single group.

Q. Is such unification a long way off, in your opinion?

A. Yes, but it will never come about as long as one doesn't take the first step.

Q. Has any consideration been given to the design of the new building?

A. Yes, by the Committee. We have talked about a two-story building. It would be made up of separate sections for each individual society but would have common mailing and other service sections which would reduce operating costs.

Q. Would this encompass all society office facilities?

A. No. Publications of each society would have to have offices in New York, I believe.

Q. Are there any major disadvantages to uniting in an engineering center?

A. I think that any time you get into a unification you lose a good deal of freedom as an individual. If one partner is taken on, then each has only a half-say in running the business. Take on two partners, and each has a one-third say.

Q. Has it been decided that the advantages outweigh the disadvantages?

A. That was considered very intensively and extensively by Council during the period when Bill Nichols was president of A.I.Ch.E. in 1953. At that time a fund-raising organization was called in and gave an opinion that we could raise the money needed for a building just to house the A.I.Ch.E. It should be an even easier job to raise the funds needed for joining with the other societies.

Q. Has the move of the A.I.Ch.E. to its new headquarters at 25 West 45th Street, New York City, affected the prospects for joining the other societies in an engineering center?

A. No, it was a necessary stopgap measure which has not been regarded as a permanent solution to our problem. Council has decided we will no longer consider moving to our own building, but will consider moving in with the other societies.

Q. What do you think will now happen?

A. I think other offers will come in. The Philadelphia's new offer (equalling Pittsburgh's) is attractive although I would still vote in favor of Pittsburgh.

Q. Are you particularly for or against New York City?

A. If New York were to make a sufficiently attractive offer, I would think the five governing boards would say, "yes, we accept." I personally prefer being out of New York, however, in a smaller community where our influence would be felt to a greater degree.

Q. What will be the mechanism for processing further offers?

A. I suppose that the five societies will set up another committee. However, I don't think the A.I.Ch.E. should enter into any further consideration of the project unless the confusion created by U.E.T. is eliminated. All during the Committee's functioning, the U.E.T. clouded and befuddled the picture.

Q. Will the decision of the five societies have to be unanimous?

A. Definitely.

Q. What do you think the A.I.Ch.E. will do?

A. That depends entirely on Council. Once the decision is made to go in with the joint venture, it cannot be backed out of. But before making the final decision, Council has everything to say about what A.I.Ch.E. will do. I think that for the long pull, for the benefit of the engineering profession, it would be well for us to go into this joint venture. *However, now is the time to lay down the ground rules under which we would be willing to enter.* Now is the time to consider them well and make sure that we are doing what we think is best for the engineering profession and the chemical engineers.

Q. Are there any signs of lack of unanimity?

A. Yes. D. V. Terrell of the Civil Engineers has withdrawn his society's support for the resolution.

Q. Do you know why he did this?

A. I am reading from D. V. Terrell's statement to Elgin Robertson, Chairman of our Committee: "Since this final report does not present a positive, unqualified recommendation that I can support and present and defend before my board, I must decline to sign the report of the Five Presidents dated February 2nd, 1955."

Q. Any concluding remarks?

A. I would like to close by reiterating, for goodness sake let's make sure we have established good and sound ground rules for this partnership before we enter into it. I think each member of Council should take this question back home with him and sleep on it—eat on it—drink on it—talk to his friends that have A.I.Ch.E.'s interests at heart and really thrash the thing out before we move into a partnership of this nature.

Q. How about the individual members of the Institute?

A. I think any members of the Institute that have any views on this subject—and I don't mean crackpot or off-the-cuff views—should, after giving the matter due consideration, write their views to the Executive Secretary, Mr. F. J. Van Antwerpen, at New York Headquarters.

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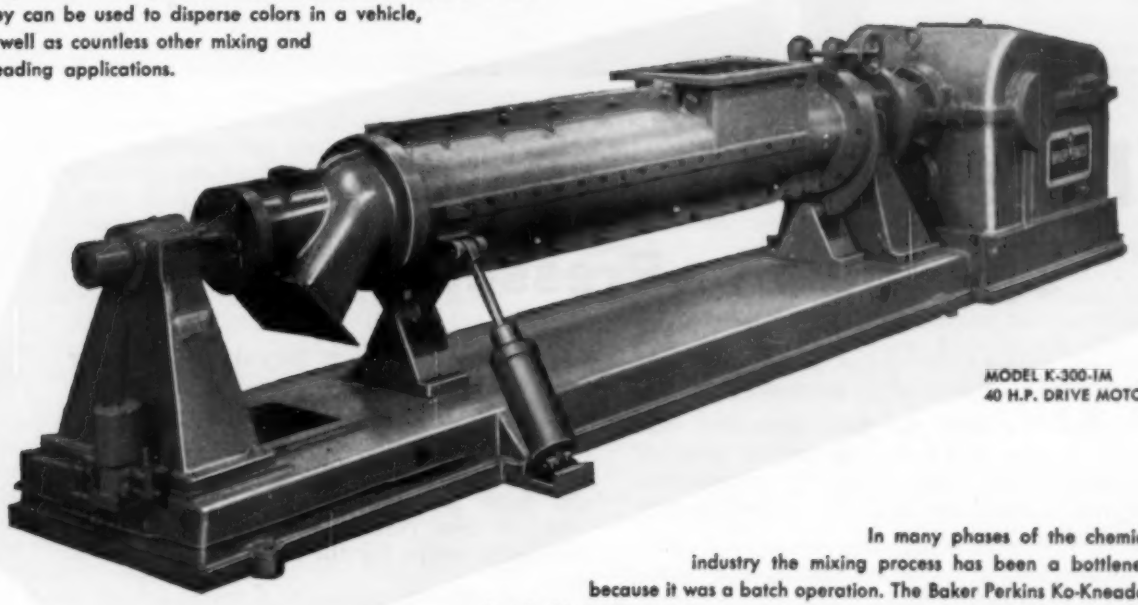

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CEP *trends* IN PROCESSING

EPOXY RESINS

Another versatile new resin is beginning to make its bid for the big time. Epoxy resins, discovered by Devoe & Raynolds only about seven years ago, have already reached an annual volume estimated at around 30 million pounds.

Rooters for the epoxy optimistically forecast a volume of around 100 million pounds or more within a few years because of the remarkable set of unusual properties which they possess. They have high dimensional stability, are tough, and resist wear and chemical corrosion especially by alkalis. They make the strongest chemical "glues" yet known. They will stick almost anything to anything with a bond so strong that the materials will break before the bond under stress.

The biggest field so far is in protective coatings in such diverse places as household washing machines and in chemical and soap plants. There is a growing use in the electrical and electronic field to make plastic "pots" for delicate gadgets. One of the most interesting of the newer uses is in direct competition with metals for making plastic dies and for glass fiber reinforced pipe. Some experts think that epoxies will offer serious competition to polyesters now widely used with glass fibers for auto bodies and other things.

The discovery of the epoxies was not accidental but the result of planned research. Scientists for Devoe drew a picture of the kind of molecule they wanted—something different from an ester—and then set about to make it. Raw materials are epichlorohydrin, made by Shell Chemical as a by-product of making glycerin from petroleum, and bisphenol made by Dow.

The Swiss Ciba company has its own process and is also a producer. Shell Chemical Co., subsidiary of Shell Oil, took out a license from Devoe in 1948 because it was already a maker of raw materials. It is now the largest producer and tripled its output in 1953 Borden Co. is another producer. Last year Union Carbide & Carbon Corp. also took out a license from Devoe, and Dow Chemical Co. is reported to be considering going into the business too. More lately there have been hints that Hercules Powder Co. may be interested.

The largest use of the resins now is in finishes for special uses and about 50 paint manufacturers are now using them. Used as an undercoating for washing machines the finish resists alkalis in the soap. The resin does not retain its original whiteness very long, however, so that it is not feasible to use it in surface coatings of household equipment or on refrigerators, for example.

The Colgate-Palmolive Co. has been using it to paint pipes and tanks in its plants. Steel plants have been using it to paint around pickling vats where it apparently will stand up for years under very severe corrosive conditions.

Used on a gymnasium floor the epoxy finishes have stood up under basketball games and dances for three years. It is also being recommended for floors in shops that have heavy traffic.

About 75% of all epoxy resins made now go into paint but other uses are coming on fast.

Another interesting new field for epoxies is in dies for forming metal parts. The dimensional stability and toughness of these resins are some of their advantages. The dies are reinforced with glass fibers. Already Republic Aviation, Douglas, Lockheed and Convair are using epoxies in tooling for stamping out plane parts. Epoxies are also being used in laminations for structural parts of the planes. Plastic tools are also getting into the automobile industry and the appliance industry. Some enthusiasts are forecasting that plastics might take over 75% of all dies in the motor industry in the next ten years.

Along this line, epoxies provide a quick and cheap method of making repairs to automobile bodies. Strips of glass cloth treated with the resin are applied in layers over a dente panel or fender, treated with heat, and then painted to match the rest of the car.

Since expoxies are excellent insulators and do not shrink or swell, they are finding increasing use in the electrical industry as plastics in which delicate parts such as transistors can be imbedded, a process called potting. This makes it possible to ship the electrical equipment without its being thrown out of alignment by jarring. The resin is also used in making printed circuits. The resin is also used with glass fibers to make laminated boards, instrument panels and the like. The Navy has used the resins to apply a quick, fast patch to pipes if they crack or burst.

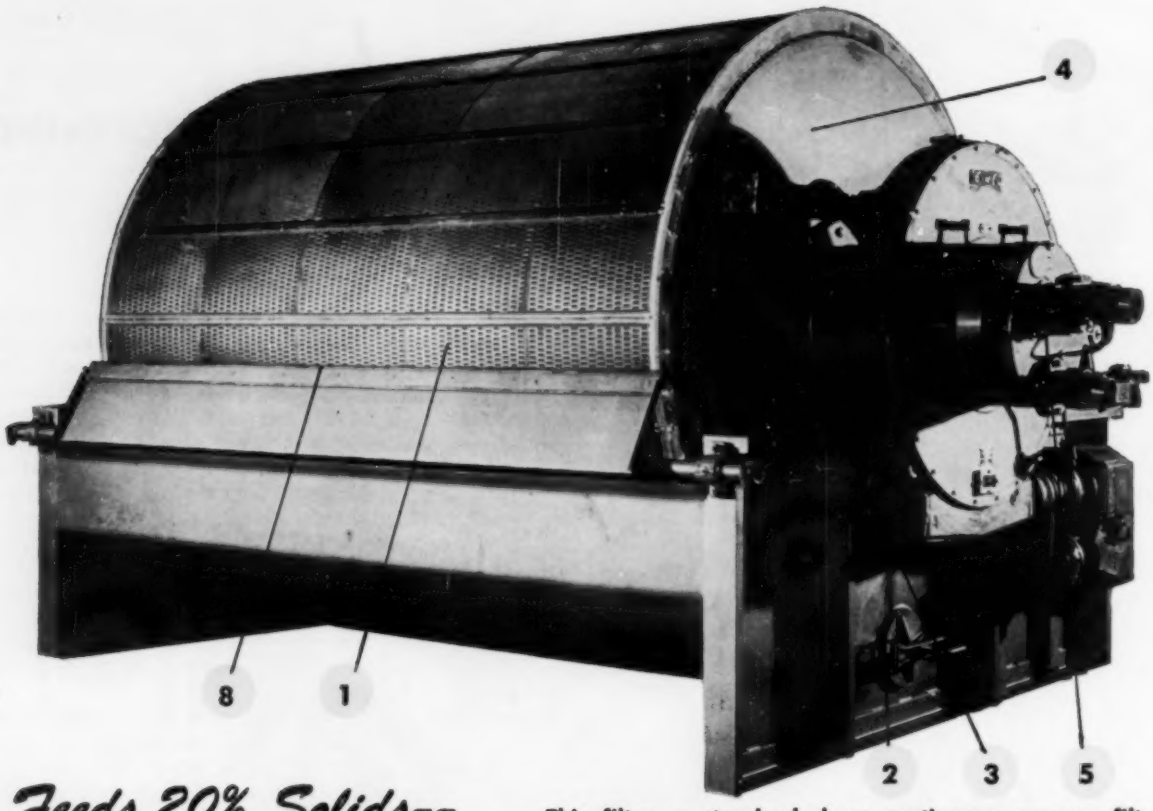
As adhesives the epoxies are almost spectacular. Used to bond metal to metal, the bond is about as strong as welding. They will bind glass to metal, plastics to metal, metal to ceramics, rubber to wood or steel, and all sorts of other materials to each other in almost unlimited combinations and variations.

They are being used, for example, to make structural panels made of an inner honeycomb frame covered with metal sheets. One of the elevator firms is using this method to make walls and doors for elevators. Epoxy adhesives are used to glue abrasives to metal. They have been used to bond joints in plates in heat exchangers made from light metals.

In the field of pipes and tanks for oil companies the new resins are expected to make another inroad into the use of metals. Epoxy glass fiber pipe will stand higher pressures than some of the other plastic pipe and resists corrosion better. Pipe of this type is already in use carrying corrosive sour crude oil and salt water. Shell is also said to be experimenting with the same technique to make oil storage tanks. Some authorities estimate that the oil industry alone might eventually be able to take 30 or 40 million pounds of epoxy resins.

So far one disadvantage of the resins is that they are expensive. They cost from 60 cents to 90 cents a pound. However, they can be blended or "alloyed" with other cheaper resins to bring down the cost.

Significantly, Shell Chemical has recently announced a cut in price of epichlorohydrin from 37 to 33 cents/lb. This will lead to further reduction in the price of the resin.



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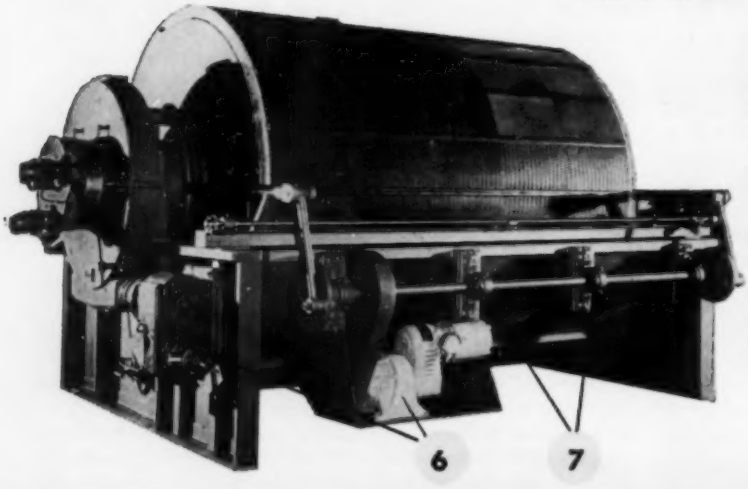

In operation a dutch weave wire cloth is caulked in the grooves and the snap blow lifts the cake from the panel away from the drum surface so that the (8) rubber tipped blade never touches the drum.

All Eimco filters are engineered and designed with the idea of prolonging cover or bag life. Eimco engineers will consult with you in the selection of the correct media for best filtration and longest life and supply you with samples of Eimco media for your own laboratory work or will advise you on shipment of samples to Eimco Research Center for free filtration analysis.

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CEP what's in this issue...

you may be interested in—

Will there be a National Engineering Center - (p. 24); and will it be in Pittsburgh? These and related questions were asked in an exclusive interview with C. G. Kirkbride, who has been close to developments.

Know the Trends - (p. 29); Flash - new feature . . . a "regular" from now on . . . C.E.P. takes you behind the scenes of the business side of processing - revealing salient facts about (this time) fast-growing epoxy resins.

Will You . . . or the Chemical Engineers in Your Employ . . . Be Drafted? - (p. 107) C.E.P. brings you a special analysis of the forces which are presently working for a better Selective Service policy.

Dust Collection Goes Scientific - (p. 110) Featured theme of this Issue - dust collection - has been studied and reported on by some of the top men in the field. Work was done at DuPont Experiment Station. Cyclones were used - both dry and with water injection.

Maintenance - What Will It Cost? - (p. 122) When planning new plant facilities, it's important to be able to know what the annual cost for maintenance will be. Glauz, of Diamond Alkali, has allowed us to reproduce his experience-charts.

Spray Drying - (p. 126) Better know-how on two little understood-phenomena - recirculation of gas within the chamber and relationship between final particle and original droplet diameters - will be the outcome of this paper.

How to Select a Plant Site - (p. 135) is outlined in six "easy" steps by Smith of Carbide & Carbon.

A New Method for Determining Distillation Equilibria Data - (p. 138) for close-boiling materials is presented by Rose & Biles of Penn State.

The Shell Rotating Disc Contactor - (p. 143) is a new plant-tested liquid-liquid extractor. Consists of a sectionalized tower equipped with a vertical rotating shaft. Discs on the shaft rotate and do the work.

Finned Tubes - (p. 147) are excellent heat transfer devices . . . A method for the calculation of their finside coefficients is described by Clarke & Winston.

Company Organization - (p. 152) is boiled down into three practical systems - based on function, product, and region - by management consultant Sargent.

Titanium (p. 34) - the wonder metal - will be available to the process industries in considerably larger quantities for the balance of the year, according to Rem-Cru - who supplies the first of a series of Reference Sheets.

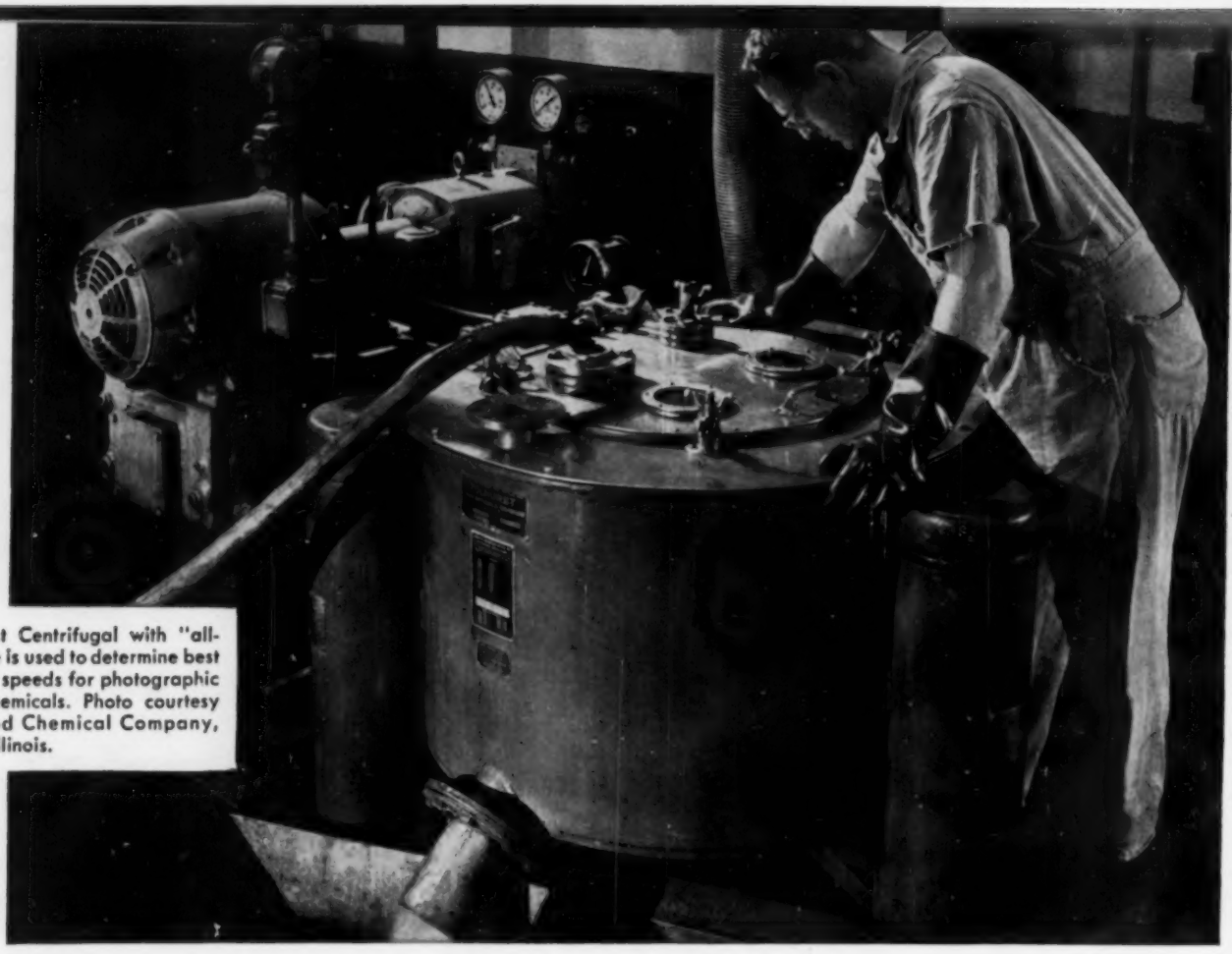
One-Day Meeting - (p. 36) . . . In Beaumont, Texas, to be exact . . . is briefly reviewed.

Roundup in Texas - (p. 40) Git yore shootin' irons oiled up for the big National Meeting in Houston.

Whitman - (p. 62); The chemical engineer who has been given the tremendous job of organizing and running the forthcoming UN International Atoms-for-Peace Conference in Geneva.

Money - (p. 96) comes into News & Notes discussion, in changes in Institute Meetings accounting practices.

-- J. B. M.



This Tolhurst Centrifugal with "all-speed" drive is used to determine best centrifuging speeds for photographic and fine chemicals. Photo courtesy of Ringwood Chemical Company, Ringwood, Illinois.

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About Many Things

Welcoming a new addition to the family is a traditionally joyous occasion—particularly so when, as in our case, it is the A.I.Ch.E. Journal. Launched at a time when other societies are voicing problems over maintaining publication services in the face of inadequate revenue, the Institute's program reflects a combination of careful planning, willingness to take a bit of a chance, and a good measure of faith in the future . . . by its leaders.

By meeting the growing need for a publication which will serve the science of chemical engineering at its fundamental core, the Journal—under the leadership of its editor, Harding Bliss—will doubtless help the field progress and grow.

The importance of the field served by the Journal can be likened to that of the foundation of a building. Applied chemical engineering *depends* on the basic, theoretical advances—builds *on* them. Advancement of our industrial technology would indeed be short-lived were it not for the effort of those specialists who are satisfied only if they are learning more and more about the secrets of nature—which in our case have to do with properties of matter and its conversion.

It is with sincerity that we say "best wishes and lots of cooperation, Harding."

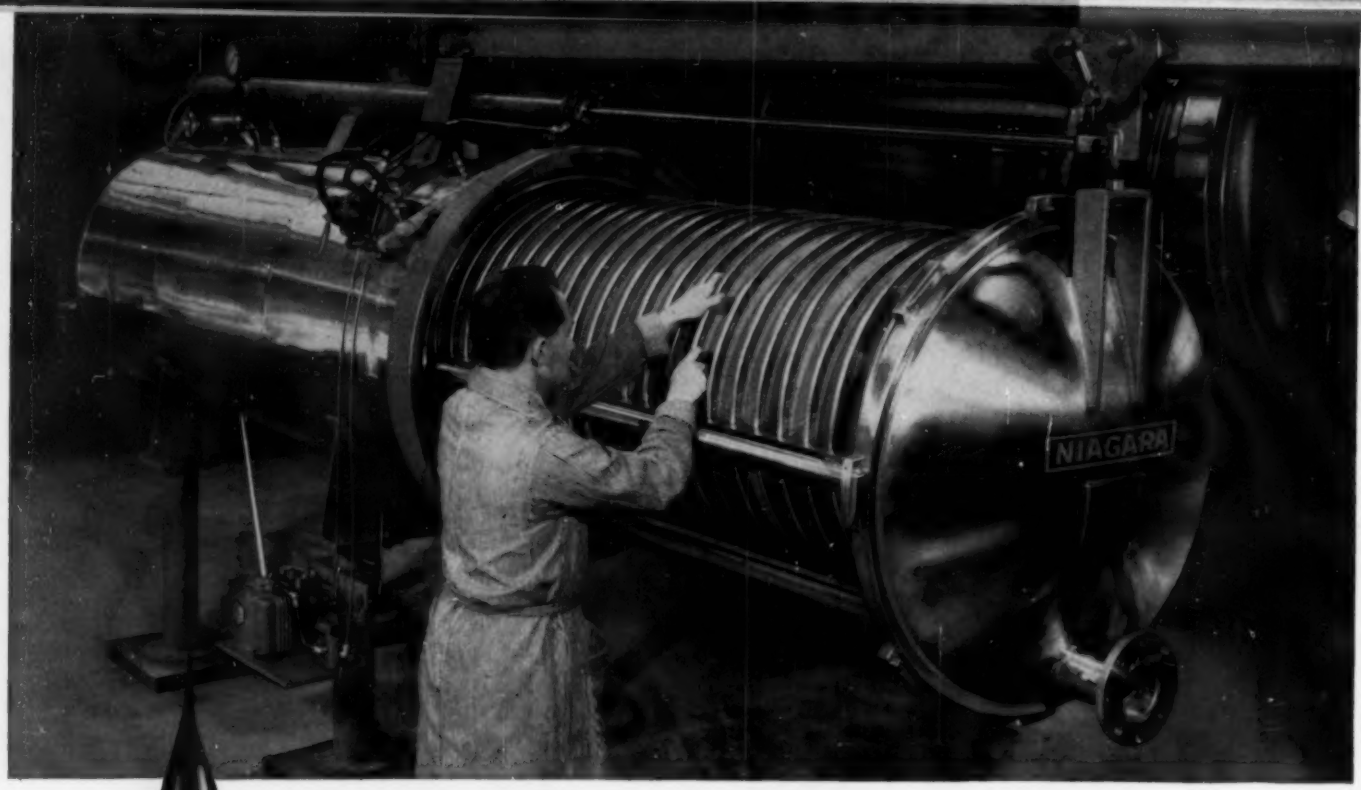
C.E.P. presents in this issue the verbal portrait of a man (Walt Whitman, page 62) which tells how a chemical engineer developed his ability to "get along" with people—to the degree of being entrusted with a job that may greatly affect the peace and welfare of people throughout the world.

Improved recognition for the engineer as a professional man continues to be striven for in important areas. One of these, which has to do with a drive to bring about improvement in legislation on military manpower, will call a good deal of attention to the value of the professional worker's services, regardless of how the efforts pay out in Congress. This is so because industrial and educational institutions are now making themselves heard, both in and out of congressional committees, on the degree to which our technologic age depends on the correct use and conservation of the services of our engineers and scientists.

Civilian engineers and scientists working for the military services make up another important area where professional recognition is being advanced. This time, it is through the efforts of the Congressional Committee on Government Operations, Sub-committee on Military Operations. A report published last August recommended that each Service give serious consideration to the organizing of top level civilian scientists and technicians into advisory committees which would participate in highest planning councils considering problems concerning research and development programs.

At the present, we understand this subcommittee is about to be refurbished with new members. It is sincerely hoped that the new Committee's efforts, starting with the base laid down by the previous subcommittee's recommendations, will be continued with vigor.

JBM



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- ☆ Hydraulically operated quick-opening cover standard on Niagara Horizontal Filters and is available as an extra on Vertical Filters.
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THE GREAT manpower DEBATE

A major effort is under way to gain further legislative recognition of the value of, and need for, conserving the Nation's technologic strength as represented by its engineers and scientists. This is being closely tied in with the Administration's proposal before Congress at this time calling for revision of the Universal Military Training and Service Act of 1952 to create a strong trained reserve. The professional groups, represented by Engineers Joint Council, believe that great advances would be attained through creation of an over-all civilian-military agency at Cabinet level—a National Manpower Board. This Board would screen continually and revise specialized manpower allocations and deferment classifications.

In the following article, C.E.P. endeavors to bring before its readers a clear picture of the issues and actions being taken, as seen from the professional viewpoint.

National security has come to depend increasingly upon the capacity of our nation to produce goods, materials, and services necessary to maintain a strong and flexible economy, as well as to develop and produce the world's most superior weapons. Manpower requirements for this purpose grow larger every day. This is due in part to the increasing complexity of our technology. It is also because no assessment of the availability or plan for the use of manpower for national security, or for any other purpose, can be complete without consideration of these ever-growing requirements. We can not hope to match our potential adversaries in terms of mere numbers of men. In a unique way the preservation of our way of life will depend not only on the maintenance of strong military forces but on our keeping a safe lead in the technological race which is very evident in the background of preparation for conflict.

It is more evident now than ever that scientific knowledge plus engineering equals power as never before known in the history of the world.

This lesson has, unfortunately, not been lost on our potential enemies. Recent studies and analyses of the Soviet educational structure and its product provide unmistakable evidence that their entire educational structure has been (and is) polarized in the direction of the fullest exploitation of its intellectual potential for engineering and science. Not only have numbers of Soviet graduates in engineering and science increased steadily; this growth rate has now caught up with and surpassed our own.

Until recently it was fashionable to discredit the quality of Russian technological effort in the face of its growing quantity. We now have increasing evidence that this attitude on our part constituted "whistling in the dark." Our smug self-confidence in our continuing superiority is in the process of being diluted by growing concern.

It is important to note here that the growth and development of American technology, which all concede to be the bedrock foundation of our national security, has not been by simple, but by logarithmic progression. This can be demonstrated as follows:

The National Science Foundation, in its annual report for the year ending January 30, 1954, presented some information on the ratio of workers in our economy to engineers and scientists and other technicians. In 1870 there were 1,100 workers for each engineer and scientist. By 1910 the number of workers had decreased per engineer and scientist to 200. In 1950 there were only 60 workers to each engineer and scientist in the United States. The real qualitative implications of this for technological manpower cannot be understood until we realize that our industrial working force has grown enormously during this same period. With these facts in mind it can be seen why our tremendous industrial structure would be seriously weakened by the withdrawal of too many of its brains.

Another reason for the growth of technology in our country has to do with the extent to which our scientific and engineering community is involved in defense-related research and development activities. In addition are the research and development efforts by industry whose expenditures for the year 1953 had reached an annual $1.8 billion.

In the case of engineers, only about half of our resources have been graduated from engineering schools since 1947. It is not surprising that in spite of this we have experienced in this country since 1950 a demand for these persons far beyond the available supply. Many are convinced that, in terms of the educational development of our professional potential in our country to meet the technological demands of our times, we have already reached the ceiling unless extensive programs are launched to encourage a proportional increase in the number of our qualified young people who actually go on to some kind of professional training. Thus

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The above is taken from a statement presented before the House of Representatives Armed Service Sub-Committee No. 1 on March 1st, 1955, by Maynard M. Boring, Chairman, Engineering Manpower Commission of Engineers Joint Council. This is stated to be on behalf of the E.M.C. and the Scientific Manpower Commision (S.M.C.), for the following organizations constituent to the Commissions: A.I.Ch.E., A.S.M.E., A.S.C.E., A.I.M.M.E., A.W.W.A., A.I.E.E., S.N.A.M.E., A.S.E.E., A.A.A.S., A.C.S., A.G.I., A.I.B.S., A.I.P., A.P.A., F.A.S.E.B., P.C.M., and P.C.S.A.C. Present with Mr. Boring were M. H. Trytten, H. A. Meyerhoff, T. H. Chilton, and W. T. Cavanaugh.

it is indicated that, in the event of an emergency, our resources of highly trained manpower on hand will without question be the major ultimate limiting factor in our capacity for mobilization. Our resources in technological manpower would barely be adequate to meet all known and probable national security needs only if they were properly distributed between and efficiently utilized by military and supporting productive activities. In other words, it is of the utmost importance that we learn to make the most of what we have—because the promise of absolute increases in the supply are poor indeed. The key to efficient manpower use is based on the *principle of selection.*

It is interesting to note that after its most comprehensive study of this problem the so-called Appley Committee of the Office of Defense Mobilization came to exactly the same conclusion in its report forwarded to the President by Dr. Arthur Flemming (Director, O.D.M.) last year. It concluded:

"The call to military service of men having critical civilian skills only upon the basis of military needs for such skills is necessary to achieve maximum availability of manpower for military and supporting activities."

In other words the Appley Committee concluded that our technical manpower situation is such that the military should have only those engineers and scientists and other technical people as it can use as such. We agree.

We were very happy, therefore, to see the acknowledgment of this point by the Assistant Secretary of Defense for Manpower and Personnel, Mr. Carter Burgess, when in his presentation before this group he said:

"When we think in terms of a reserve of several million men, we must consider the needs of essential industry and the community. During the Korean emergency, there were frequent instances in which individuals suffered severe hardships as a result of the recall of reservists and essential industries were seriously inconvenienced. We want to be able to do our screening in advance in a reasonably calm atmosphere and to avoid the repetition of such a situation in the event of emergencies."

Advantageous Features of Administration's Bill

In our opinion the Administration's proposed Bill (H.R. 2967) under discussion goes a long way toward establishing a realistic National Reserve Plan. Its strong points in our view are the following: *First,* it is a plan. This is more than we now have. It would be unpleasant to think of the chaos in the military and even more in essential industry that would result from a mobilization, partial or full, under present circumstances. *Second,* it provides for a Ready Reserve and measures necessary to keep it really ready. *Third,* it provides for the constant screening of the Ready Reserve to insure that persons possessing critical skills will now be retained in numbers beyond the requirements for these skills except for persons who have military skills for which there is an overriding requirement. *Fourth,* it provides a Standby Reserve whose members would be called through a process of selection. *Fifth,* it provides that any member of the Standby Reserve who has not completed his period of service in the Ready Reserve may be transferred back to the Ready Reserve when the reason for his transfer to the Standby Reserve is no longer accepted. *Sixth,* it provides for the six-month training plan including special quotas for persons with critical skills.

The Bill's Deficiency

The Bill has, however, in our view, one deficiency of sufficient magnitude to defeat the many constructive aspects which it includes. This deficiency consists in the retention within the Department of Defense of the entire discretion in the construction of the reserve forces. We believe that the Bill is defective in that it does not provide for a National Manpower Board within the Federal Government at Cabinet level.

We are convinced that this tremendous authority over our entire national security through the administration of manpower policies should be exercised by a Board chaired by the Director of the Office of Defense Mobilization and composed of members to insure that both the military and the supporting civilian elements of the economy are effectively represented. We feel that this Board should be charged, among other things, with:

1. **Allocating manpower among the several claimants including the military.**
2. **Establishing a list of critical occupations and a list of essential activities.**
3. **Establishing the criteria by which selective service registrants are to be classified.**
4. **Establishing criteria governing the screening of the Ready Reserve and the transfer from that Reserve to the Standby Reserve.**
5. **Establishing the criteria by which reservists are to be called to active duty from the Standby Reserve.**
6. **Establishing the criteria governing appeals by employers or by persons recalled to active duty from the Standby Reserve.**
7. **Establishing quotas and criteria for admission to the six-month training plan including special quotas for persons in critical occupations.**

The various claimants for manpower have relative needs which change with great rapidity. In view of the radical changes in military and industrial technology and in our vulnerability to attack, the ratio of armed forces personnel to supporting research and production personnel should be continuously reviewed and adjusted as necessary to achieve the greatest potential strength. Only such a board can adequately perform this function.

Screening—A Collective Effort

It is interesting to note that in his presentation before this Sub-Committee, the assistant Secretary of Defense for Manpower and Personnel (Mr. Burgess), recognized the need for such a comprehensive approach to this problem when he said:

"Although this screening process would be administered by the military services, in the over-all it would be a collective effort. Criteria and policies for this screening process would be developed by the Department of Defense in conjunction with the Office of Defense Mobilization, the Departments of Labor, Commerce, Agriculture, and other interested agencies."

It is difficult to understand why in view of this recognition of the need, statutory provisions for such procedure are not contained in the Bill.

It should be clear that we are in no way advocating the dilution of control of the Ready Reserve by the Department of Defense. Our remarks concerning the collective approach through the national manpower board have to do with the *construction* of the reserve force—not with its recall and use. Everybody agrees that the Department of Defense, being responsible for the military defense of our country should, and must, have the authority to control its Ready Reserve.

However, because neither the Department of Defense nor any other single agency bears the total responsibility for national security broadly considered, it should not have total manpower authority however willing it may be to exercise it. The histories of the War Manpower Commission, the National Security Resources Board and more recently the Office of Defense Mobilization show that such a board or similar device to attain the same ends with equal assurance is an absolute necessity.

Two instances of current problems indicate the need for such a Board:

We are advised that this Bill contemplates no statutory limit on the size of the Ready Reserve. We have been given various estimates of the order of magnitude. Simple arithmetic indicates that the size of the Ready Reserve is a key question on this whole situation. If it's too big, then the screening process and the Standby Reserve are nullified as practical working things. We certainly believe that the size of the Ready Reserve is largely a military decision based on military and strategic factors, but it has to remain within an overall framework of reasonableness in terms of overall manpower needs and presumably budgetary consideration. This in our view should be a major function of the national manpower board or its equivalent.

Appley Committee Report

If the national manpower board now existed, it might be effective in the resolution of another current problem in relative manpower needs that is getting more dangerously ridiculous with each passing day. Its elements are these. The need for manpower for the military is lower now than in some time. The need for technological personnel in industry is greater now than ever before in our history. Yet the Selective Service System continues its serious inroads on such personnel through the application of the doctrine of Universal Military Service. This goes on while 1,500,000 men await induction. Of these, one-quarter million have already been found physically qualified. Meanwhile, the average age of induction with its consequent waste and hardships continues to rise. In other words, the application of current policy in terms of current needs is in exactly the wrong direction. This is not our opinion alone. Here is what the Appley Committee said about this precise situation:

"The margin of skilled manpower for expanded war production is extremely narrow in the light of modern requirements. To strip American industry of an essential number of these persons during partial mobilization puts the nation in peril of not being able to meet its production requirements in the event of a full emergency."

In our view the national manpower board could bring real relief to such a situation by use, for example, of the six-month training plan as a safety valve on our manpower pool. *This would most certainly be our recommendation in the absence of a real system of Universal Military Training.*

Legislative Proposals

A brief listing of the various bills which have been introduced into the 84th Congress to amend existing military manpower legislation:

H.R. 2967 This Bill would establish the Administration's National Reserve Plan. In general, this would provide for the enlistment of men under the age of 19 years in the Reserve for a period of ten years. Such individuals would be trained actively for six months and would then enter the Ready Reserve. The Bill also provides that the President may specifically authorize persons over 19 years of age with critical skills engaged in critical defense-supporting industries to fulfill their military obligation by entering the six months training (10 year) program. The present liability imposed by the Selective Service Act would be continued and those inducted would be obligated to serve a total of eight years—two on active duty and six in the reserves. The Bill provides for the screening from the Ready Reserve to the Standby Reserve of those specialized personnel not needed in the Ready Reserve as such and who possess no overriding military skill. The Bill further provides that the Ready Reserve may be called to extended active duty in time of national emergency proclaimed by the President, whereas the Standby Reserve may not be called except in time of war or of national emergency declared by the Congress. These individuals would be subject to a determination of availability by the Director of Selective Service.

H.R. 3005 This Bill provides for the extension of the power of Selective Service to induct men until July 1, 1959. It has already been passed by the House of Representatives.

H.R. 2847 Introduced in Congress by Representative Carl Hinshaw "to amend the Universal Military Training and Service Act to provide for the discharge and continuing deferment of certain persons of exceptional scientific, technical or engineering ability aptitude," this Bill will be the focal point of discussion when the matter of the need of continuing selectivity is discussed before the House Armed Services Sub-Committee under the Chairmanship of Representative Paul Kilday.

S. 969 This Bill has been introduced in Congress by Senator Ralph Flanders, and amends the Universal Military Training and Service Act of 1951 relative to the process of selection. Its purpose is to revive both the name and the process of selection so that the latter will be retained as a part of the purposes of that Act.

S. 2 A Bill to provide a vitalized and equitable reserve plan for the Armed Forces; to provide for the operation of the National Security Training Corps, and for other purposes. This Bill has become known as the "American Legion Bill." It would implement the Universal Military Training part of the Universal Military Training and Service Act of 1951.

H.R. 3005 has already been passed by the House, with amendments, A companion bill has not yet been introduced into the Senate. The Senate may consider the Administration's Selective Service and Reserve Legislation in a single combined bill. In the House, a Sub-Committee is currently holding hearings on the Administration's Reserve Plan (H.R. 2967) and another Sub-Committee under Representative Paul Kilday will soon schedule hearings on the Hinshaw Bill (H.R. 2847). How soon, or whether, these bills will be referred to the full Committee and be given a rule for debate on the floor of the House cannot be predicted. As for Senate legislation, no firm schedule has yet been set, although the Senate proposed to start hearings with a minimum delay.

The above information was taken from Engineering and Scientific Manpower Newsletter No. 74, dated February 28, 1955.

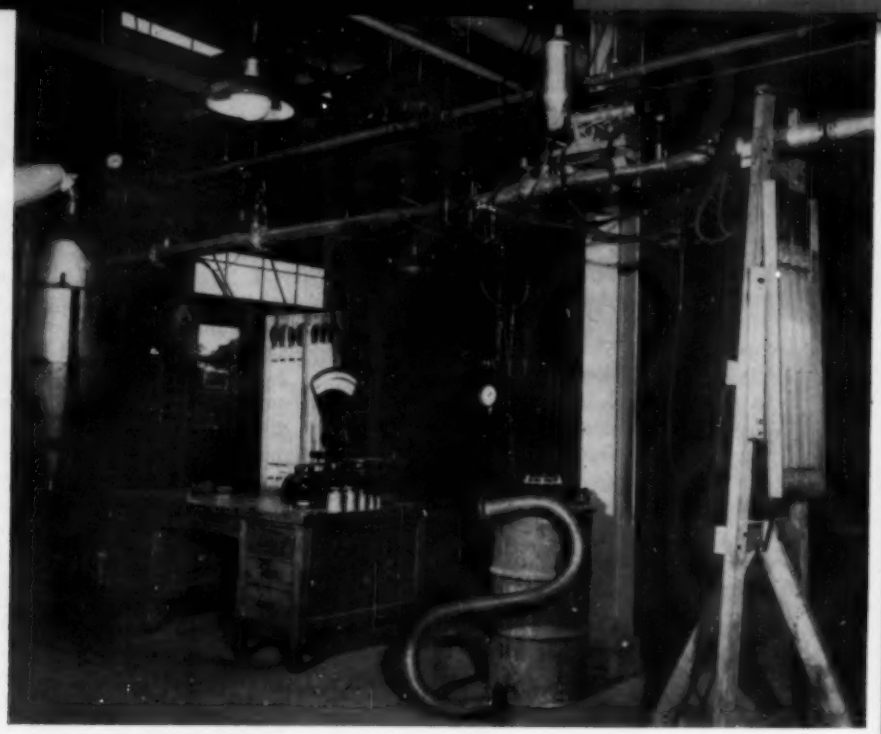

Fig. 3. Photograph of semiworks-scale scrubbing equipment.

performance of wet dust scrubbers

C. E. Lapple and H. J. Kamack

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Wilmington, Delaware

Current interest in air pollution abatement makes it increasingly important to evaluate methods for removing efficiently and economically small particulate matter (dust or mist) from gas streams. One such method with great potential applicability involves contacting the particle-laden gas with a liquid, usually water. Devices which make use of this method are known as "scrubbers," of which many varieties of commercial types are available. Literature on scrubbers, although extensive, deals largely with performance tests on specific units or specific applications. Little information is available which can be used for fundamental design of a scrubber or to determine the comparative effectiveness of the known contacting devices. The purpose of this investigation was to obtain the comparative performance characteristics of many of the simpler contacting devices and, if possible, to obtain an insight into the fundamental mechanisms which control the performance of a scrubber.

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Scope of Investigation

The various types of commercial equipment were surveyed to determine what were the basic contacting devices used in them. The devices selected for experimental evaluation and testing were simple enough so that the results of the tests could be applied to more complex devices.

In all the tests aerosols were prepared by feeding dust at a uniform rate into a high-velocity air stream. The collection efficiency and pressure drop of various contacting devices when handling this dust-laden air were measured at various air flow rates, water flow rates, and dust loadings. Tests were first conducted on a laboratory scale and then repeated on a semiworks scale. The semiworks units were essentially geometrically similar to the laboratory units having 2.8 times the linear dimensions of the corresponding laboratory units. In one case (venturi contactor) data on a still larger unit were available for comparison. Various tests dusts were also used. The types of devices evaluated and the dusts used are summarized in Table 1. In addition, exploratory tests were conducted to determine the effects on collection efficiency of using hot water and of injecting steam into the air stream.

The laboratory and semiworks test

THE EXPERIMENTAL EQUIPMENT

equipment consisted in the order specified of an air meter, a dust feeder and disperser, a contacting device, a cyclone entrainment separator, and a bag filter in series. The bag filter was used for dust-loss measurements. In some runs the cyclone was used as the sole contacting device as well as the entrainment separator.

Laboratory-Scale Investigation

EQUIPMENT

The air was metered with a critical flow nozzle by the use of calibrated nozzles 6AN and 8AN (4).

The dust feeder consisted of a vibrated vertical tube in which the dust charge was placed and allowed to drop through a constriction into

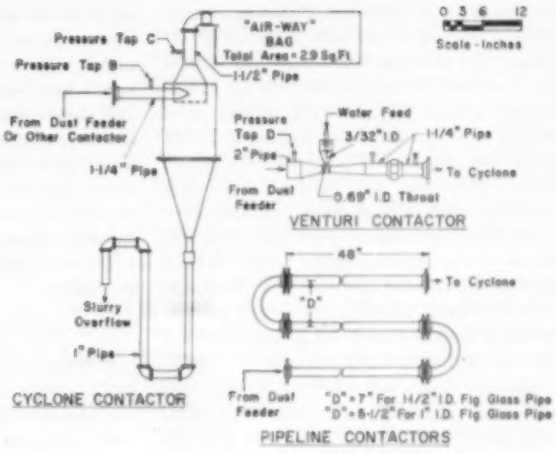
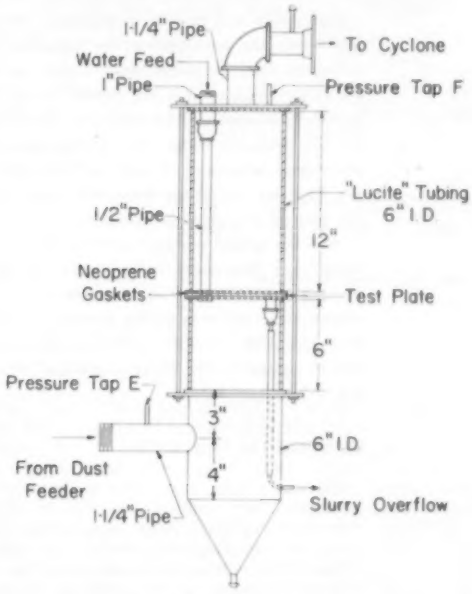


Fig. 1-A. Laboratory-scale scrubbing devices.



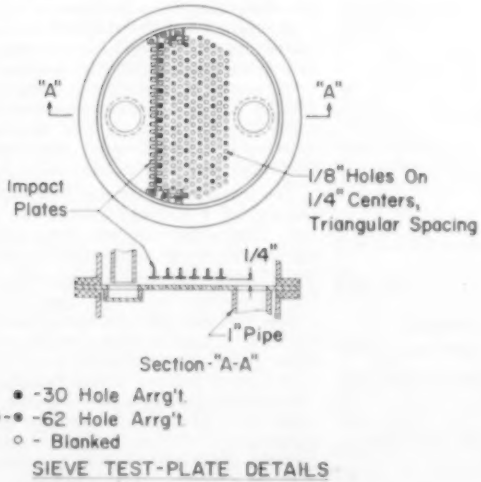
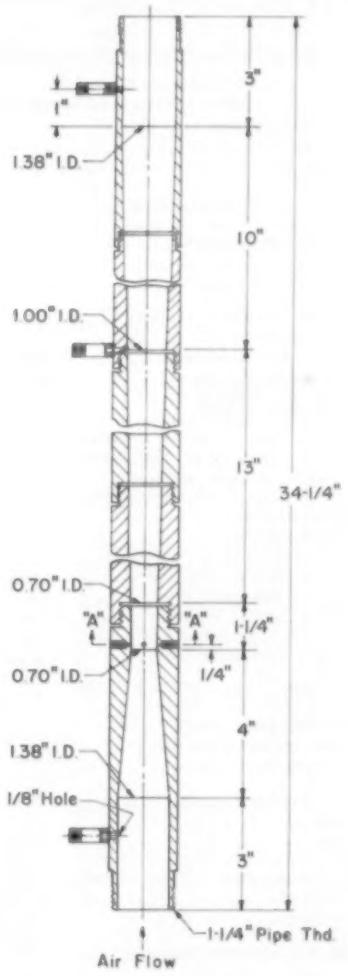


Fig. 1-B. Laboratory-scale scrubbing devices.



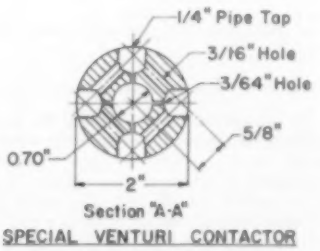


Fig. 1-C. Laboratory-scale scrubbing device.

the throat of a horizontal dispersing venturi where it became mixed with the metered air stream. The throat of this venturi was 0.50-in. I.D. From the dispersing venturi the air passed through one of the contacting devices, then through the cyclone, and the air-permeable paper bag shown in Figure 1 to the atmosphere. (See Figure 1 for details.) The orifice contactor, which is not shown, consisted of a 1½-in. diam., 16 gauge stainless steel plate containing a ¾-in. concentric orifice (4) with a knife edge on the upstream face and a 45° bevel. For evaluation as a scrubber, this orifice was inserted between gaskets in the flange connecting the dispersing venturi and the cyclone.

Although Figure 1-A shows the pipeline contactor with two 180° bends and three 48-in. long straight sections, arrangements of both two and four 180° bends, each without the straight sections, were also tested in the case of the 1-in. contactor. In all cases the straight sections and bends were standard flanged glass pieces connected with standard flanges and gaskets obtained from Corning Glass Company, and the 180° bends were all located in the same vertical plane with the motion of the air either horizontal or progressively upward. The special venturi contactor shown in Figure 1-C was a carefully machined unit, whereas the other venturi contactor was a welded unit, none too carefully made, with projecting lips at the joints on the inside.

WATER INTRODUCTION

In the case of the cyclone contactor, the pipeline contactor, and the orifice contactor, water was introduced through a ¼-in. Schedule 40 pipe into the top side of the 1¼-in. Schedule 40 pipe at the outlet of the dust-dispersing venturi and was discharged from the apparatus by overflowing from the seal leg under the cyclone shown in Figure 1-A. In the case of the sieve-plate column, water was introduced onto the plate through a ½-in. Schedule 40 pipe as shown in Figure 1-B. In this case the major part of the water discharged through a separate overflow in the base of the column, and the liquid entrainment from the column through the cyclone seal leg (which became significant when the air velocity through the holes in the plate exceeded approximately 70 ft./sec.) was discharged through the cyclone seal leg.

With the venturi contactor (Figure 1-A), three methods of feeding water were used. In the concentric water feed arrangement, the open end of the water nozzle was inserted into the throat of the venturi through the ¼-in. hole in the side of the throat wall, which connects the throat of the venturi with the small closed hopper. The water nozzle consisted of a ⅛-in. O.D. steel tube (3/32-in. I.D.) brazed into a ¼-in. copper tube, with a sharp 90° bend at the free or open end of the ⅛-in. tube. The end of the nozzle was located concentrically in the venturi throat and pointed downstream. For the side water feed arrangement, the ⅛-in. tube was pulled up into the venturi feed hopper so that the water dribbled into the throat through the ¼-in. hole connecting the venturi with the hopper. For the upstream water feed arrangement, the water was introduced through a ¼-in. pipe at the discharge end of the dispersing venturi as in the case of the pipeline contactor.

With the special venturi contactor (Figure 1-C), water was introduced in two separate ways, through the four ports at the throat and upstream as in the case of the pipeline contactor and the other venturi contactor. With both venturi contactors the water discharged through the cyclone seal leg.

Table 1.—Scope of Investigation [xx]

Scale	Equipment Type *	Dusts Used: Talc A	Talc B	Titanium Dioxide	Ilmenite
Laboratory	8-in. cyclone contactor				
	Dry	x	x	x	
	Wet	x			
	Pipe-line contactors (vertical)				
	1-in. contactor				
	2 180° bends and 3 48-in. straight sections	x	x	x	
	2 180° bends	x	x		
	4 180° bends	x			
	1¼-in. contactor (24-in. straight sections).		x		
	1½-in. contactor (2 180° bends and 3 48-in. straight sections)	x			
	Venturi contactors				
	0.7-in. venturi				
	concentric throat water inlet	x	x		
	side throat water inlet	x			
	upstream water inlet		x		
	0.7-in. special venturi				
	side throat water inlet		x		
	upstream water inlet		x		
	¾-in. orifice contactor	x			
	6-in. sieve-plate column **				
	with impact plates	x			
	without impact plates	x			
Semiworks	23-in. cyclone contactor				
	dry		x		x
	wet		x		
	Pipe-line contactor (2⅞-in. S-bend)				
	horizontal		x		
	vertical		x		x
	2-in. special venturi contactor		x		
	2⅛-in. orifice contactor				x
	2⅛-in. orifice and 2-in. special venturi (in series)		x		
Pilot-Plant	3½-in. special venturi contactor [x]		x		

* In all runs the cyclone was used following the other units indicated.

** With the sieve-plate column the number of holes in the plate and the liquid level on the plate were also varied.

[x] This unit was tested by Chemical Construction Corporation at Philadelphia.

[xx] In most of the evaluations air rate was varied over a two-fold range, water rate over a two-fold range, and dust loading over as much as a ten-fold range.

EXPERIMENTAL PROCEDURE

The air flow rate was measured and controlled by a critical flow nozzle. Pressure-drop readings were taken across each piece of equipment by means of vertical xylene-filled glass manometers, by the use where necessary, of a small air bleed to prevent water accumulation in the pressure taps.

The dust feed rate was controlled visually by adjusting the vibration of the feeder. It is estimated that the feed rate was maintained constant during the course of each run within ±20% of the average for the run. Normally a weighed charge of from 100 to 200 g. of dust was fed into the apparatus during each run over a timed interval of 2 to 20 min., from which the dust feed rate was calculated.

The water flow rate was controlled by the reading of a pressure gauge in the water line. The water rate was measured in each run by collecting and weighing the effluent water from the equipment over a timed interval.

The dust that escaped from the scrubbing equipment was collected in a paper bag filter placed on the exit end of the cyclone (see Figure 1-A). In each run the bag was brought to moisture equilibrium by running from 10 to 15 min. at the prescribed operating conditions without feeding dust. Several check measurements indicated that this time interval was adequate. The bag was weighed rapidly both after reaching

EXPERIMENTAL EQUIPMENT *(Continued)*

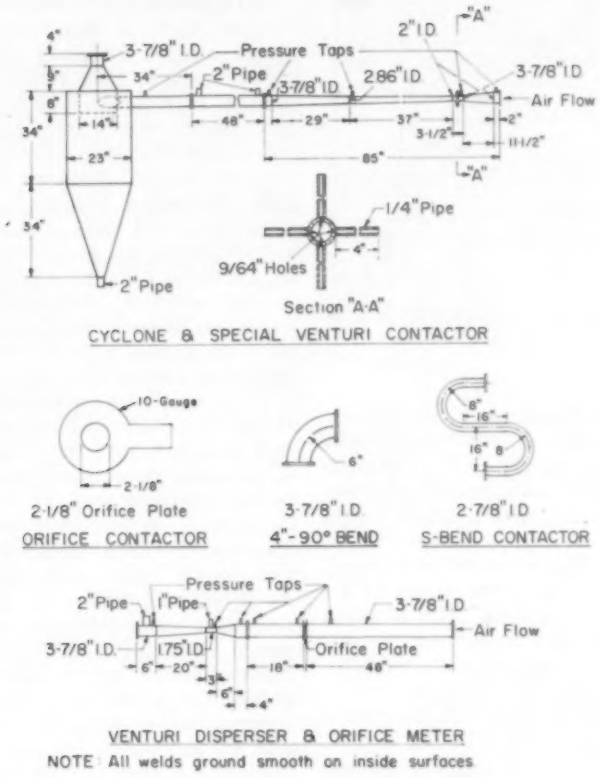


Fig. 2. Semiworks-scale scrubbing devices.

moisture equilibrium and after the run to obtain the weight of uncollected dust by difference.

No entrainment of water droplets from the cyclone was ever observed. There was also no visible sign of any dust passing through the paper bag in the case of talc or ilmenite dust. With the titanium dioxide dust, however, a smokelike bleed-through was observed for the first few seconds of a run with a new bag, but thereafter the exhaust from the bag appeared clear.

In the runs where no water was introduced, dust material balances were checked. With talc all material balances obtained checked within 3%. With titanium dioxide, however, it was impossible to obtain reasonable material balances owing to the large amount of dust which adhered to the inside walls of the cyclone. It was not considered worth while to unbolt and clean the cyclone after each run for the sake of a material balance.

EXPLORATORY TESTS

Crude exploratory tests were conducted to determine the effect on collection of degree of water atomization and of steam injection. In these water spraying tests a 1¼-in. tee was mounted on the outlet end of the dust-dispersing venturi. A 24-in. length of 1¼-in. pipe followed by the 8-in. cyclone was screwed into the run of this tee. The water line was ⅛-in. Schedule 40 pipe came in through the branch of the tee and terminated in a nozzle pointing downstream concentrically in the pipe. This nozzle contained four No. 74 drill holes arranged so that the jets from all four holes converged at a point.

In the runs where steam was used, the steam was introduced through a ¼-in. copper tube inserted into the 1¼-in. pipe at the discharge end of the dispersing venturi. This copper tube was sealed at the end and contained a hole, approximately 9/64-in. diam., in the side. The tube was positioned so that the hole was at the center of the 1¼-in. pipe and faced downstream. The stream flow was regulated by controlling the steam pressure on the nozzle. The nozzle was calibrated for steam flow by immersing the nozzle in a known weight of water and noting the rate of increase in water temperature. Steam pressures of 7 and 19 lb./sq.in. gauge were used. In all cases the amount of steam introduced was so small that it had a negligible effect on pressure drop due to the rate of gas flow through the equipment.

Semiworks-Scale Investigation

EQUIPMENT

The semiworks equipment (Figures 2 and 3) was geometrically similar to the corresponding laboratory equipment with a linear scale ratio of 2.8:1. The main exception to direct similarity was the cyclone. Whereas the laboratory scale had a 1.38-in. diam. inlet and a 1.61-in. air outlet, the semiworks cyclone had a 3.85-in. diam. inlet and outlet. Also the S-bend was made from a single piece of copper tube, whereas the corresponding arrangement on the laboratory scale consisted of flanged 180° glass bends. In the semiworks equipment, the air flow was metered with an orifice meter with the use of sharp-edged plates and vena contracta taps. The dust was fed into the throat of the dispersing venturi by a horizontal vibrating feeder (see top-center, Figure 3). The hopper on the feeder was airtight.

When the 2⅛-in. orifice was evaluated as a contactor, it was inserted between gaskets in the flange joining the cyclone and the 48-in. long straight section. When the S-bend was used, it was also inserted at this point, lowering or moving sideways the upstream equipment depending on whether the S-bend was used in a vertical or horizontal position respectively. The S-bend corresponds to two of the 1-in. 180° bends in series used in the laboratory-scale tests.

WATER INTRODUCTION

In the tests involving the special venturi (Figure 2) as a contactor, the water was introduced through the four ports at the throat of this venturi. In the tests on the other units, the water was dropped into the 2-in. port on the top of the upstream end of the 48-in. long straight duct. When the other units were evaluated, the dust-laden air passed through the special venturi, although no water was introduced at the venturi throat.

EXPERIMENTAL PROCEDURE

Runs with the semiworks equipment involved the same general procedure used in the laboratory-scale tests. The dust charge was usually 500 to 1,000 g. The dust escaping from the cyclone was collected in a bag made of Orlon acrylic fiber (Duplan Fabric No. 8033) with a total cloth filtering surface of 27 sq.ft. The air rate was measured and controlled with an orifice meter by the employment of standard methods of calculation (*1*).

Pilot-Plant Data

Test data were obtained by Chemical Construction Corporation on its pilot plant unit with Talc B furnished by the authors. The venturi contactor employed was essentially geometrically similar to the special venturi contactor used in both the laboratory- and semiworks-scale investigations and had a throat diameter of 3.5 in. The entrainment separator consisted of a pot approximately 30-in. diam. by 30-in. high with a bottom tangential inlet, and an off-center bottom gas outlet, both approximately 12-in. diam. The weighed dust charge was dropped from a vibrating feeder into a high-velocity inlet nozzle comparable in effect to the dispersing

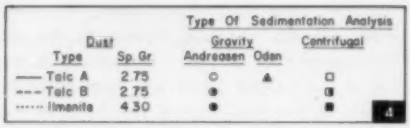
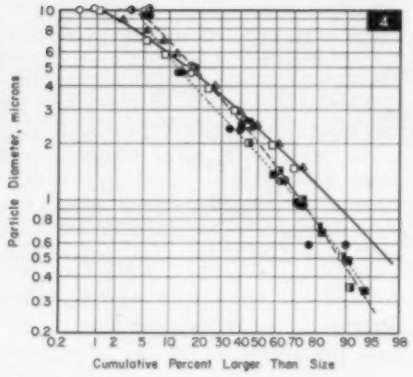


Fig. 4. Particle size analyses of dusts used.



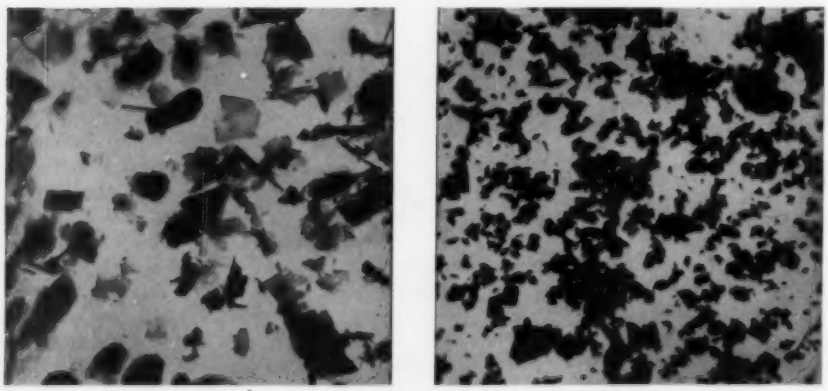
venturi used by the authors. Collection efficiencies were measured by sampling the gases leaving the entrainment separator.

Dusts Used

Four dusts were used in the study: Talc A, Talc B, titanium dioxide pigment, and ilmenite. Talc A was Grade SF talc obtained from Whittaker, Clarke & Daniels in New York City in 1940. Talc B, obtained from the same manufacturer in 1948, had superseded the previous SF grade and was designated as Grade No. 399 magnesium silicate. Visually, Talc B looked and behaved differently from Talc A when handled. Talc B also had a higher bulk density than Talc A. The titanium dioxide was a pigment which was passed through a small Mikro-Pulverizer hammer mill to break up lumps. The ilmenite was a finely divided dust obtained by grinding ilmenite ore. Particle-size distributions are shown in Figure 4 for the Talc A and B and the ilmenite. No particle-size analyses were made of the titanium dioxide; most of this material lies between 1 and 0.1μ particle diameter.

Figure 5 presents electron micrographs of the ilmenite and Talc B dusts. Mounts for these electron micrographs were made by simply placing the standard collodion-coated mounting screen in the powder and shaking off the excess dust before placing it in the electron microscope. The talc particles appeared to consist of thin plates mostly in the range of 0.3—0.5μ thick. This is shown by the transparent appearance of many of the particles as well as by the presence of some particles on edge.

To confirm this judgment, the mounting film was ruptured in the electron microscope by increasing the electron beam intensity; and the action of the particles was observed. The breaking film would curl up and, in so doing, would turn particles successively on edge and face up. In this manner it was observed that the particles which appeared large in the original field were actually thin plates lying face up. The ilmenite consisted of granular particles with a highly irregular surface. While some of the larger ilmenite particles shown in Figure 5 could conceivably be aggregates of smaller particles, no breakup or change in configuration of these particles was observed when the film-breaking technique just described was used.



Talc B Ilmenite

Fig. 5. Electron micrographs of talc B and ilmenite.

Pressure Drop Results

In Figures 6 and 7, the pressure drop for each piece of equipment is shown plotted against the water loading expressed as gal./1,000 cu. ft. air. The pressure drop plotted is only that across the specific contactor indicated and does not include adjacent units, such as bag filter or cyclone, also used during the run. The water loading is that calculated from the rates of feeding water and air and is not necessarily the concentration of water at any specific spot in the equipment. For each piece of equipment, pressure drop measurements were made over a series of operating conditions without dust feed.

The pressure drop measurements made during the dust-collection runs check well with those made prior to dust feed in all cases except those involving the cyclone contactor and the venturi contactor with a concentric water inlet. The pressure drop across the venturi was slightly higher when dust was fed owing to accumulation of dust on the concentric water inlet pipe and the resultant restriction of the venturi throat. For the cyclone, on the other hand, the pressure drop was lower owing to the accumulation of dust on the cyclone walls and the circulation of some froth in the cyclone. Both factors act to reduce swirl in the cyclone and hence pressure drop. In one case where the pressure drop was especially low, examination of the cyclone after the run revealed a handful of froth circulating in the bottom of the cyclone cone. These factors, erratic in nature, account for the spread in the pressure drop data for the cyclone.

In the pipeline, orifice, and side- or upstream-inlet venturi contactors, pressure drop increased with water loading. In the pipeline and side-water-inlet venturi contactors, pressure drop was approximately directly proportional to the apparent density of the water-air mixture, not allowing for water hold-up in the system. For the orifice contactor, the increase was not so rapid, presumably because of less opportunity for acceleration of the liquid. In the case of the concentric-water-inlet venturi, the water loading caused only a small increase in pressure drop. This was due probably to the jet-type inlet, which carried the water out of the venturi throat before a large portion could be accelerated. The velocity of water leaving the water nozzle was estimated to be in the range of 15 to 50 ft./sec. before contacting the air.

In the case of the special venturi (Figure 6-D), introducing water through the four throat ports gave a higher pressure drop than when it was introduced into the duct ahead of the venturi. This is due probably to the fact that, in the former case, the water is more intimately

Curve	Data Symbol		Air Velocity, ft./sec. (based on inside pipe cross-section)
	Dust Fed	No Dust Fed	
------	▽	▼	45
------	△	▲	67
– – –	□	■	98
——	○	●	143

6-A

Curve	Data Symbol		Air Velocity, ft./sec. (based on inside pipe cross-section)
	Dust Fed	No Dust Fed	
------	△	▲	30
– – –	□	■	44
——	○	●	63

6-B

Curve	Data Symbol		Air Velocity, ft./sec. (based on free throat cross-section)
	Dust Fed	No Dust Fed	
------	△	▲	159
– – –	□	■	232
——	○	■	337
– – –	⌂ ■	▲	206 ✪
——	⌂ ●	▲	298 ✪

Concentric water inlet
✪ Side water inlet ⌂ ⌂ ; Upstream water inlet ● ■

6-C

Data Symbol		Air Velocity, ft./sec. (based on free throat cross-section)
Dust Fed	No Dust Fed	
△	▲	137
□	■	200
○	●	291
△	▲	137 ✪
⌂	▲	200 ✪
⌂	▲	291 ✪

Water added at throat
✪ Water added ahead of throat

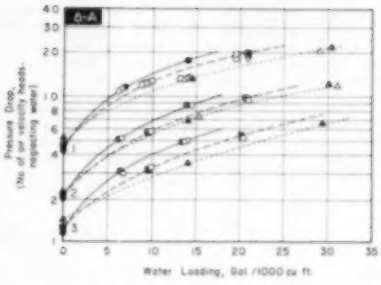
6-D

Curve	Data Symbol		Air Velocity, ft./sec. (based on orifice aperture)
	Dust Fed	No Dust Fed	
------	△	▲	120
– – –	□	■	175
——	○	●	255

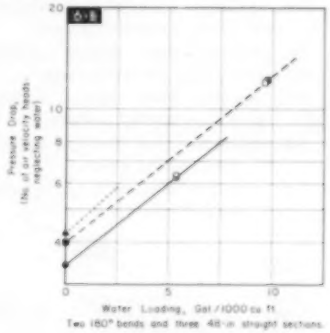
6-E

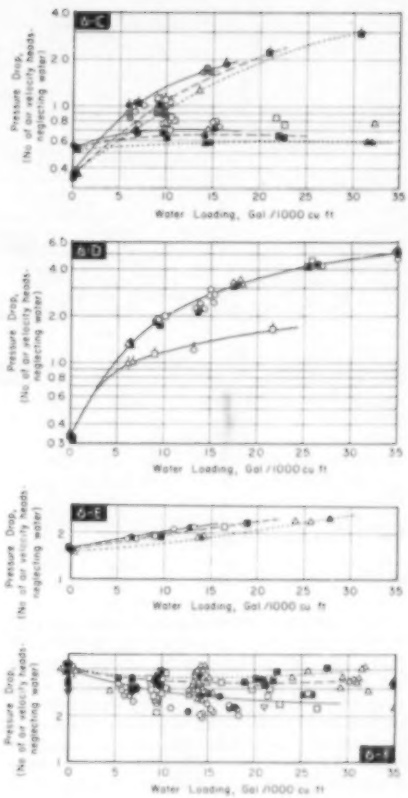
Curve	Data Symbol		Air Velocity, ft./sec. (based on inlet pipe cross-section)
	Dust Fed	No Dust Fed	
------	▽	▼	24
------	△	▲	35
– – –	□	■	51
——	○	●	75

6-F



1. Two 180° bends and three 48-in. straight sections.
2. Four 180° bends.
3. Two 180° bends.


6-B
Pressure Drop, (No. of air velocity heads, neglecting water)
Water Loading, Gal./1000 cu. ft.
Two 180° bends and three 48-in straight sections.



RESULTS

Pressure Drop Data

Fig. 6-A. Pressure drop through laboratory-scale 1-in. contactor.

Fig. 6-B. Pressure drop through laboratory-scale 1½-in. contactor.

Fig. 6-C. Pressure drop through laboratory-scale 0.7-in. venturi.

Fig. 6-D. Pressure drop through laboratory-scale 0.7-in. special venturi.

Fig. 6-E. Pressure drop through laboratory-scale ¾-in. orifice.

Fig. 6-F. Pressure drop through laboratory-scale 8-in. cyclone.

contacted with the air and accelerated to a greater extent than in the latter.

The pressure drop across the sieve-plate column ranged from 1 to 3 velocity heads for the range of air and water rates used, based on the free area of the sieve plates. The data, however, were not sufficiently comprehensive to provide any basic correlation.

Figure 8 gives a comparison of the pressure drop data for geometrically similar laboratory- and semiworks-scale units. In general, the agreement is very good at the higher velocities. The semiworks special venturi gave a slightly lower pressure drop than the laboratory unit. This is due likely to the presence of a gasketed joint on the downstream end of each, which was included in the pressure drop measurement. In the laboratory unit it was known that this gasket extended an appreciable distance (1/16 to 1/8 in.) into the duct, which is proportionately much greater than for the semiworks unit in which the gasket projection was less than 1/16 in.

At low velocities the semiworks vertical S-bend gave a higher pressure drop than the corresponding laboratory unit. At the low velocities the water probably is not as fully accelerated as it is for the laboratory unit. However, this failure to accelerate will result in an accumulation or concentration of water in a vertical bend with a resultant additional pressure drop due to hydrostatic head. Since the semiworks bend involved almost three times the elevation change as the laboratory unit, this hydrostatic effect apparently more than compensated for the decrease in pressure drop due to lower water acceleration at the low gas velocities. This explanation would appear to be confirmed by the results obtained for the horizontal semiworks S-bend (Figure 7-A) for which the pressure drop at a given water loading did decrease for the lower air velocities. The semiworks orifice showed no effect of air velocity on pressure drop expressed as number of orifice velocity heads, whereas the laboratory unit showed a decrease at the lower velocities and higher water loadings. The explanation for this is not obvious although there was a slight difference in the orifice plates. The semiworks orifice contained a square-edged hole, whereas the laboratory orifice had a knife-edged hole with the knife edge on the upstream side.

By comparing the curves of Figures 6-F and 7-E, it will be noted that the semiworks cyclone (23-in.) gave a higher pressure drop than the laboratory unit (8-in.). This is due to the fact that the air outlet duct on the 23-in. unit was proportionately smaller than on the 8-in. unit, and the pressure drop would be expected to vary approximately as the inverse square of this diameter.

In Figures 6, 7, and 8, the unit of water loading has been chosen as gal./1,000 cu.ft. as this is commonly used in dust-collection practice. If these data are to be applied to gases or liquids other than atmospheric air and water, it is suggested that, as an approximation, the curves of Figures 6-8 be used directly after the abscissa is converted to units of pounds of liquid per pound of gas.

Curve	Data Symbol: Dust Fed	Data Symbol: No Dust Fed	Air Velocity, ft./sec. (based on inside pipe cross-section)
-----	△	▲	70
– – –	□	■	100
———	○	●	140

7-A

Curve	Data Symbol: Dust Fed	Data Symbol: No Dust Fed	Air Velocity, ft./sec. (based on inside pipe cross-section)
-----	△	▲	70
– – –	□	■	100
———	○	●	140

7-B

Data Symbol: Dust Fed	Data Symbol: No Dust Fed	Air Velocity, ft./sec. (based on throat cross-section)
△	▲	140
□	■	205
○	●	300

7-C

Data Symbol: Dust Fed	Data Symbol: No Dust Fed	Air Velocity, ft./sec. (based on orifice aperture)
△	▲	130
□	■	180
○	●	260

7-D

Curve	Data Symbol: Dust Fed	Data Symbol: No Dust Fed	Air Velocity, ft./sec. (based on inlet pipe inside cross-section)
-----	△	▲	40
– – –	□	■	55
———	○	●	80

7-E

RESULTS

Pressure Drop Data—Specific

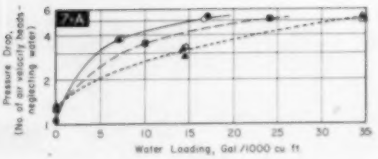
Fig. 7-A. Pressure drop through semiworks-scale 2⅞-in. horizontal *s*-bend.

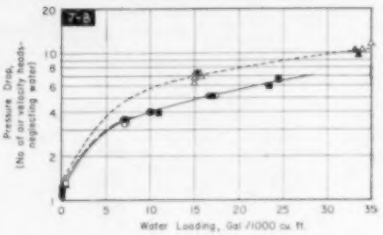
Fig. 7-B. Pressure drop through semiworks-scale 2⅞-in. vertical *s*-bend.

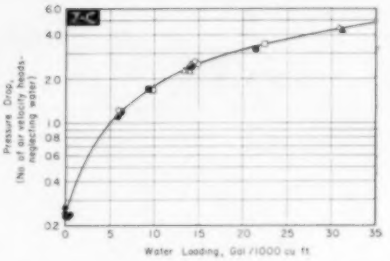
Fig. 7-C. Pressure drop through semiworks-scale 2-in. special venturi.

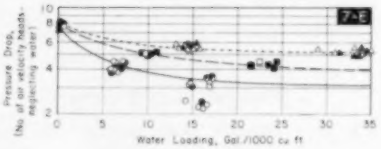
Fig. 7-D. Pressure drop through semiworks-scale 2⅛-in. orifice.

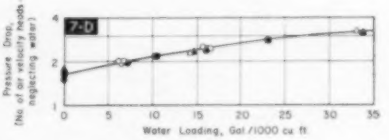
Fig. 7-E. Pressure drop through semiworks-scale 23-in. cyclone.











Collection Efficiency Results

DUST CONCENTRATION

The effect of dust concentration on collection efficiency is shown in Figures 9 and 10 in which each curve applies for a given dust, operating condition, and equipment arrangement. Only dust concentration is varied. The dust loss from the equipment appears to approach a constant value for feed dust loadings of less than 2 gr./cu.ft., but decreases rapidly for dust concentrations greater than 10 gr./cu.ft.

Curve	Equipment	Throat Velocity Range, ft./sec. (based on throat cross-section)
———	Semiworks	Water Fed At Throat 140-300
———	Laboratory	
x	Pilot Plant (Chem. Constr. Corp.)	

8-A

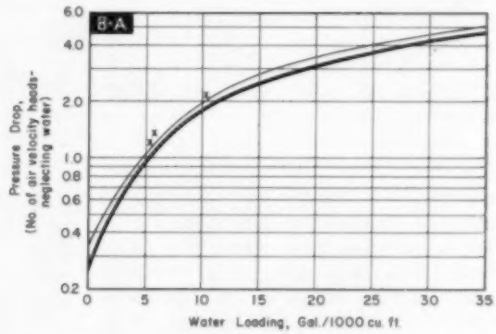
Semiworks Scale	Laboratory Scale	Nominal Duct Velocity, ft./sec. (based on inside pipe cross-section)
– – – – – –	– – – – – –	70
— — —	— — —	100 ✡
———	———	140 ✡

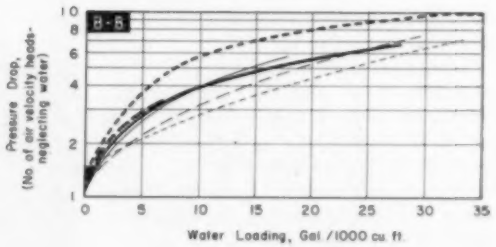
✡ Curves for these two conditions nearly coincide for semiworks scale.

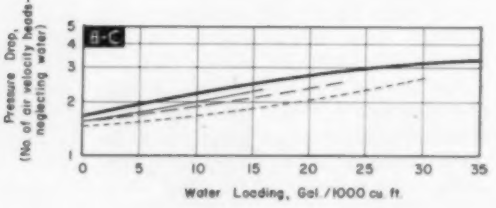
8-B

Semiworks Scale	Laboratory Scale	Nominal Orifice Velocity, ft./sec. (based on orifice aperture)
———	– – – – – –	125
———	— — —	175
———	———	250

8-C







SUMMARY RESULTS

Pressure Drop Data

Fig. 8-A. Pressure drop comparison for semiworks and laboratory scale special venturi.

Fig. 8-B. Pressure drop comparison for semiworks and laboratory scale vertical *s*-bend.

Fig. 8-C. Pressure drop comparison for semiworks and laboratory scale orifice.

RESULTS

RESULTS

Dust Concentration vs. Dust Loss

Data Symbol: Nominal Water Rate, gal./min. 0.0	Data Symbol: Nominal Water Rate, gal./min. 0.3	Dust	Data Symbol	Air Velocity, ft./sec. (based on inlet pipe inside cross-section)
○ □ ☆ ☆ ☆	■ ▲	Talc A Talc B Titanium Dioxide	○ ■ □ ◇ ◇ ☆ ◇ ▲	35 51 75

9-A

Data Symbol: Nominal Water Rate, gal./min. 0.3	Data Symbol: Nominal Water Rate, gal./min. 0.7	Dust	Data Symbol	Air Velocity, ft./sec. (based on inside pipe cross-section)
● ■ ▲ ▼ ◆ ■	○ □ ◇	Talc A Talc B	▼ ○ ● ◆ □ ■ ◆ ◇ ▲	45 67 98 143

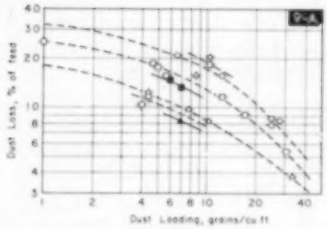
9-B

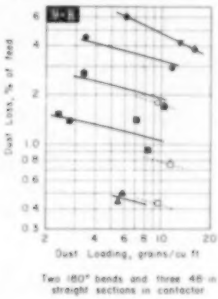
Data Symbol: Nominal Water Rate, gal./min. 0.3	Data Symbol: Nominal Water Rate, gal./min. 0.7	Dust	Data Symbol: Type Water Inlet: Concentric	Data Symbol: Type Water Inlet: Side	Air Velocity, ft/sec. (based on free throat cross-section)
● ■	○	Talc A	● ○		159
◆ ▲	□	Talc A		■	206
			■ □		232
▲	△	Talc A		▲	298
			▲ △		337

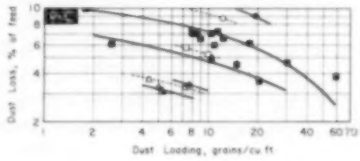
9-C

Symbol	Equipment	Dust
○	23-in. cyclone (operated dry)	Ilmenite
△ □	2-7/8-in. vertical S-bend and 23-in. cyclone	Ilmenite
●	2-1/8-in. orifice and 23-in. cyclone	Ilmenite
▲	23-in. cyclone (operated dry)	Talc B
■	2-in. special venturi and 23-in. cyclone	Talc B

10







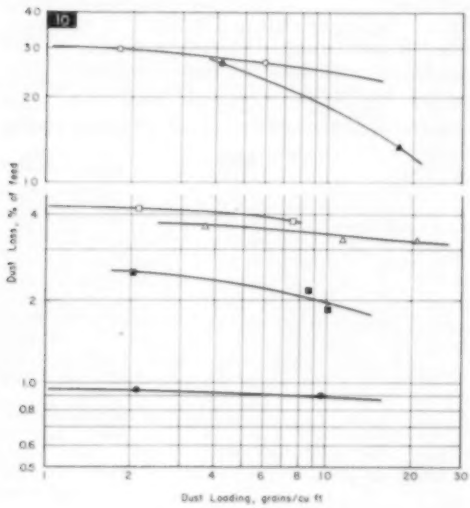


Fig. 9-A. Effect of dust concentration on dust loss for laboratory scale 8-in. cyclone.

Fig. 9-B. Effect of dust concentration on dust loss for laboratory scale 1-in. contactor and 8-in. cyclone.

Fig. 9-C. Effect of dust concentration on dust loss for laboratory scale 0.7-in. venturi and 8-in. cyclone.

Fig. 10. Effect of dust concentration on dust loss in semiworks-scale investigation.

such instances the same dust was used at a similar level of dust loss. Values so obtained are summarized in Tables 2-4. These values of dust loss were plotted then against over-all pressure drop for each arrangement of scrubbing equipment (Figures 11-16). The pressure drop plotted in these figures is the summation of that across all the units and connecting piping which contribute toward the contacting of the water with the dust. All dust loss values are on a weight percentage basis. In Figures 11, 12, 14, 15, and 16 no differentiation is made in data points for air and water rates; only for type of dust and equipment arrangement.

COMPARATIVE CONTACTOR PERFORMANCE

From Figures 11 and 12, it will be observed that, when compared at the same pressure drop and for the same dust, there is relatively little difference in performance between any of the scrubber mechanisms tested, the maximum spread in the dust loss being approximately twofold. For example, there is not much difference between a cyclone operated wet and one operated dry. At pressure drops below 2 in. water, the various scrubbing devices do not indicate any marked advantage over the dry cyclone, at least for the scale of operation involved in these tests.

It should be pointed out that in all the types of contacting devices involved in this investigation, over-all gas pressure drop is a direct measure of power input per unit of gas flow rate. Power from other sources, as from water spray velocity or mechanical devices, was negligible. A more general criterion would be power input per unit of gas flow rate [e.g., (hp.)/(1,000 cu.ft./min)].

OPERATING VARIABLES

In order to bring out the effect of secondary variables which are not specifically differentiated in Figure 11, the data for Talc A obtained with the laboratory-scale equipment (Table 2) were cross-plotted and interpolations or extrapolations were made to obtain dust-loss comparisons at fixed water loadings and air rates. These are plotted in Figure 13 against over-all pressure drop for specific scrubbing-equipment arrangements. Data for Talc B or

This is believed to be due to the degree of dispersion of the dust that is accomplished by the dispersing venturi. In other words, a dust present at high concentration is effectively coarser because of agglomeration than the same dust at low concentration. It is not believed that this can be due to mutual interaction of dispersed particles, because, even at the higher concentrations involved in these tests, the particles are statistically 20 to 80 diam. apart. Instead it is felt that this effect is due to a failure of the dispersing venturi to disperse completely the bulk dust. At the low concentrations the dust still may not be completely dispersed; but it appears to approach a constant degree of dispersion. Thus, each concentration results in an effectively different dust and, to evaluate equipment performance, results must be compared at the same dust concentration.

It will be also noted that, with ilmenite dust, the dust concentration had considerably less effect on dust loss than with talc dust. Possible explanations are given subsequently under "Type of Dust."

METHOD OF DATA PRESENTATION

As indicated above, equipment performance comparisons must be made at the same dust loading. As it was not possible with the type of dust feeder employed to predetermine accurately the dust concentration for each run, tests were made at various concentrations. As most of the data were centered at a dust concentration on the order of 8 gr./cu.ft., this was arbitrarily selected as a reference basis for presenting comparative equipment performance. The dust loss at a dust loading of 8 gr./cu.ft. with each device at a specific operating condition was obtained by extrapolation or interpolation on a plot similar to Figures 9 and 10. Where runs were made at only a single dust concentration for a given equipment arrangement and operating condition, the dust loss to be expected at a dust loading of 8 gr./cu.ft. was obtained by extrapolation of the data on a plot of the type of Figures 9 and 10 along lines having the same slope or curvature as those obtained at other conditions or with other equipment; in

Tables 2, 3, and 4 contain a summary of the "faired" data for dust concentration of 8 gr./cu.ft. These tables list all data plotted in Figure 11-14, in addition, giving the actual air and water rates at which the tests were run.

Table 2 contains laboratory-scale data for Talc A, Talc B, and titanium dioxide. Tables 3 and 4 contain semiworks scale data for Talc B and ilmenite respectively.

Tables 2, 3, and 4 have been deposited with the American Documentation Institute Auxiliary Publications Photoduplication Service, Library of Congress, Washington, D. C. Document 5,000 is obtainable by remitting $1.25 microfilm copies and $1.25 for photoprints.

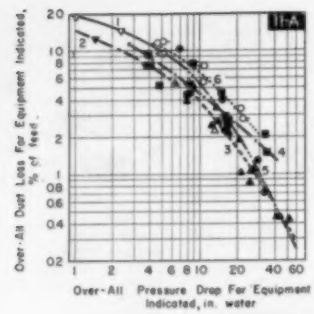
RESULTS

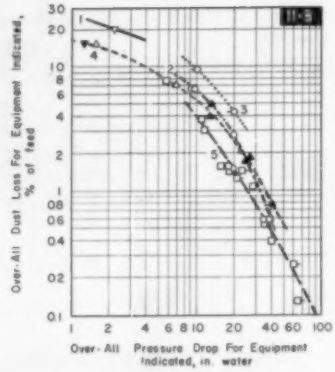
Dust Loss—Talc A

11-A Equipment	Water Feed Point	Data Symbol	Curve
8-in. Cyclone (Operated dry)		▽	1
(Operated wet)	Duct	▼	2
1-in. Contactor and 8-in. Cyclone (all arrangements)	Duct	▲	3
1 1/2-in. Contactor and 8-in. Cyclone	Duct	▲	3
6-in. sieve-plate Column and 8-in. Cyclone	Plate	■	4
3/4-in. Orifice and 8-in. Cyclone	Duct	●	5
0.7-in. Venturi and 8-in. Cyclone	Throat - Concentric	◇	6
	Throat - Side	◇	6

11-B Equipment	Water Feed Point	Data Symbol	Curve
8-in. Cyclone (Operated dry)		▽	1
0.7-in. Venturi and 8-in. Cyclone	Duct	○	2
	Throat Concentric	◇	3
1-1/4-in. pipe and 8-in. Cyclone	Duct Thru Nozzle	△	4
	Duct Thru Nozzle	▼	4
1-in. Contactor and 8-in. Cyclone (all arrangements)	Duct	▲	4
0.7-in. Special Venturi and 8-in. Cyclone	Duct	□	5
	Throat - Radial	□	5

12 Equipment	Data Symbol	Curve
23-in. Cyclone (Operated dry)	○	1
23-in. Cyclone (Operated wet)	●	2
2 7/8-in. Horizontal S-bend and 23-in. Cyclone	△	3
2 7/8-in. Vertical S-bend and 23-in. Cyclone	▲	3
2 1/8-in. Orifice and 23-in Cyclone	□	3
2-in. Special Venturi and 23-in. Cyclone	▽	4
2 1/8-in. Orifice, 2-in. Special Venturi and 23-in. Cyclone	■	5
Dust Loading = 8 grains/cu. ft.		





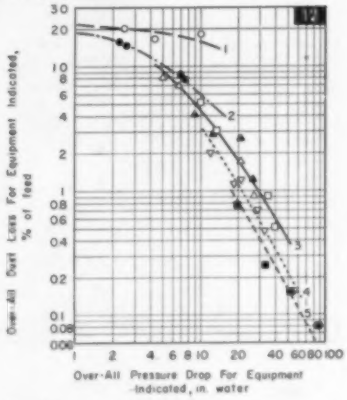


Fig. 11-A. Talc A dust loss data for laboratory scale equipment.
Fig. 11-B. Talc B dust loss data for laboratory scale equipment.
Fig. 12. Talc B dust loss data for semiworks scale equipment.

13-A ARRANGEMENT			OPERATING VARIABLES	
Contactor Diameter, in. i.d.	Number 180° Bends	No. Straight Sections (48-in. long)	Water Loading gal./1000 cu. ft.	Air Velocity, ft./sec. (In 1-1/4 in. I.P.S.) 35 51 75 92
1	2	0	10	○ △
			20	● ▲
1	4	0	10	◇ ○ △
			20	◆ ● ▲
1	2	3	10	○ □ △
			20	● ■
1-1/2	2	3	10	▼ ▽
——— 10 gal./1000 cu. ft. - - - - 20 gal./1000 cu. ft.			Dust Loading 8 grains/cu. ft.	

Water Loading gal./1000 cu. ft.	Air Velocity, ft./sec. (In 1-1/4 in. I.P.S.) 35 51 75
10	○ □ △
20	● ■ ▲
——— 10 gal./1000 cu. ft. - - - - - 20 gal./1000 cu. ft.	
Dust Loading = 8 grains/cu. ft. 13-B	

ARRANGEMENT		OPERATING VARIABLES	
Number Holes in Plate	Impact Plates	Liquid Level on Plate, inches	Air Velocity, ft./sec. (In 1-1/4 in. I.P.S.) 35 51 75
30	Present	1/4 - 1/2	⊙ ⊡ △
30	Absent	1/4 - 1/2	⊙ △
62	Present	1/4 - 1/2	○ □ △
62	Present	1/2 - 1	● ▲
62	Absent	1/4 - 1/2	○ △
——— Low level with impact plates. - - - - - Low level without impact plates. ····· High level with impact plates.			
Dust Loading = 8 grains/cu.ft. 13-C			

Type Water Inlet	Water Loading gal./1000 cu. ft.	Air Velocity, ft./sec. (In 1-1/4 in. I.P.S.) 35 51 75
Concentric	10	○ □ △
	20	● ■ ▲
Side	10	□ △
Dust Loading = 8 grains/cu. ft. 13-D		

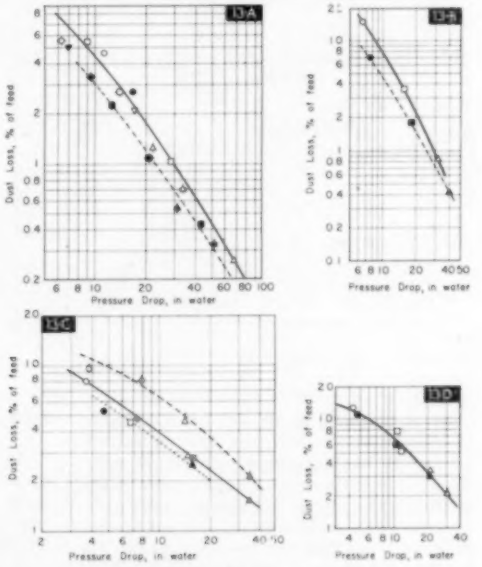


Fig. 13-A. Effect of operating variables on dust loss in laboratory-scale pipeline contactor and 8-in. cyclone (using Talc A).

Fig. 13-B. Effect of operating variables on dust loss in laboratory scale ¾-in. orifice and 8-in. cyclone (using Talc A).

Fig. 13-C. Effect of operating variables on dust loss in laboratory scale 6-in. sieve-plate column and 8-in. cyclone (using Talc A).

Fig. 13-D. Effect of operating variables on dust loss in laboratory scale 0.7-in. venturi and 8-in. cyclone (using Talc A).

RESULTS

Operating Variables vs. Dust Loss

for the semiworks equipment were not sufficiently extensive to permit such cross-plots to be made reliably.

Figure 13-D indicates that water loading had no apparent effect on the performance of the 0.7-in. venturi and cyclone arrangements over the range tested. For the pipeline contactor and for the orifice contactor, the higher water rates gave a small but significant improvement in collection, especially at the lower pressure drops.

In the case of the sieve-plate column, the results are arranged in Figure 13-C to indicate the effects of water level and impact plates. Increased water level gave a small improvement in collection efficiency. Visual observation of the column showed a violent agitation and spray formation in the column with some of the holes almost void of water at times. It is possible that the prime effect of the higher liquid level is to minimize the opportunity for gas to channel through the column without being subjected to high-velocity contacting with the water. Leaving out the impact plates over the holes in the sieve-plate resulted in a significant reduction in dust collection

efficiency. This may also be due to air channeling.

EQUIPMENT SIZE

Curves in Figure 14 taken directly from Figures 11 and 12, show the comparison between the results of laboratory- and semiworks-scale equipment on Talc B. Also included are pilot-plant-scale data on the special venturi contactor. This pilot-plant unit was almost twice the size of the semiworks contactor.

The agreement between the laboratory-scale and the semiworks-scale data for a given unit is fairly good. There does appear to be a small trend in the direction of higher collection efficiency (lower dust loss) at a given pressure drop with the larger equipment scale. This may be due to the fact that larger units have a smaller surface-to-volume ratio, so that a greater fraction of water is active in contacting particles and a smaller fraction is wasted in dissipating energy on the walls.

The semiworks cyclone operated dry gave the same order of collection efficiency as did the laboratory unit. Normally, the larger unit would have been expected to give a somewhat lower collection efficiency. However, in this case, the larger unit contained a proportionately smaller gas exit duct, which is known to improve collection efficiency, although it also increases pressure drop at a given capacity. This may have had a compensating effect. Since relatively few data were obtained with the cyclone operated dry on Talc B, nothing more than an order-of-magnitude comparison is justified.

TYPE OF DUST

Talc was chosen for most of the test work because of its ready dispersibility compared to other fine dusts. As will be noted from Figure 11, results obtained for Talc B were similar to those for Talc A in so far as general trends are concerned. In all cases the dust loss was greater with Talc B than with Talc A, as would be expected from the finer particle-size distribution for Talc B (see Figure 4).

Results obtained with ilmenite (Figure 15) and with titanium dioxide (Figure 16) were entirely different from those obtained with talc. Whereas, with talc, an increase in air velocity resulted in a relatively marked increase in dust-collection efficiency (decrease in dust loss), little improvement, and in some cases a reduction in dust-collection efficiency were obtained with ilmenite. For the same air velocity, however, an increase in water rate resulted in the same degree of improvement in dust-collection efficiency for the ilmenite as for the talc. This phenomenon is believed to be due to the degree of dust dispersion. Visual observation indicates that ilmenite is more difficult than talc to disperse in air. If the ilmenite is incompletely dispersed at a given air velocity, raising the velocity would increase the degree of dispersion. Thus, the beneficial effects of high-gas velocities on dust collection may be compensated for or even counteracted by the greater degree of dispersion at the higher velocities. In effect, one is then dealing with a different dust, from an effective particle-size distribution standpoint, at each gas velocity.

Figure 15 shows that, if comparisons of dust loss vs. pressure drop are made at the same air velocity, the curves are similar in appearance to those obtained for talc except that they are displaced to the right for increasing air velocities. The pressure drop variation for a given air rate is obtained by varying the water rate or the nature of the equipment. In view of the fact that the dust loss vs. pressure drop curves for ilmenite in the dry cyclone have passed through a peak and are descending again by the time a cyclone inlet velocity of 80 ft./sec. is reached, it is felt that the ilmenite was almost completely dispersed, or at least at an equilibrium dispersion state, at the higher air velocities tested. (It should be noted that for a cyclone inlet velocity of 80 ft./sec., the velocity at the throat of the dispersing venturi was approximately 600 ft./sec.). On this assumption, the dashed curve of Figure 15 has been drawn in by analogy from the talc curves, to indicate the performance that might be expected from a dry cyclone handling the dispersed dust. As a matter of interest, a 31-in. diam. cyclone in the plant system from which this ilmenite dust was originally obtained gave a collection efficiency of 50% at a pressure drop of about 3 in. water.

Similar results were obtained with titanium dioxide pigment (Figure 16). The titanium dioxide, by visual observation, appeared to be more difficult to disperse than the ilmenite, and the dust collection curves show a more marked deviation from the talc curves than do those for ilmenite.

Though the results of the tests with ilmenite and titanium dioxide indicate that there is an advantage in using low air velocities and high water rates for a given pressure drop when dealing with dusts that are difficult to disperse, this may or may not be the case in commercial practice. It should be remembered that in the tests the dust was fed into an air stream at the throat of a dispersing venturi. As the air flow rate through the scrubbing equipment was increased, the air velocity through the dispersing venturi also increased. In commercial practice the state of dispersion of dust in the air stream entering the scrubber will not be dependent on the air velocity in the scrubber. It is, of course, possible that further dispersion will occur in the scrubber if the air velocity is high there. However, scrubbing will proceed simultaneously with the dispersing action, so that potential dispersion due to those velocities may fall far short of being realized.

As shown in Figure 4, the ilmenite has nearly the same particle-size distribution as Talc B. Since the ilmenite particles have a greater inertia than talc because of their greater density, it would be expected that the collection efficiency for ilmenite would be greater than the collection efficiency for talc. The reverse was found to be the case. The following are possible alternative explanations.

1. Error in particle-size distribution measurements.

2. The wetting characteristics of ilmenite are less favorable to collection than those of talc.
3. The talc is dispersed less completely than the ilmenite.
4. The flat shape of the talc particles results in more efficient impaction on the water droplets owing to a greater probability of interception.
5. Electrostatic phenomena, which would probably be different for the talc and ilmenite, may play an important role in collection.

Of these alternates, items 2 and 4 appear the most reasonable. The fact that dust concentration had less effect on collection efficiency for ilmenite than on talc might be regarded as evidence for item 4. A greater probability of impaction would have the same effect as if the particle concentration were higher. Thus, relative to ilmenite, the effective concentration of talc may have been much greater in these tests from the standpoint of dispersion equilibrium.

STEAM INJECTION

High-spot evaluation of the effect on collection efficiency of steam addition to the dust-laden gases was made on the laboratory-scale equipment with Talc B. Steam rates were on the order of 2 to 3 times those required to saturate the air. Results shown in Table 2 indicated that the addition of this small amount of steam gives a fivefold reduction in the dust loss at a given pressure drop. The power introduced with the steam was negligible compared to that associated with the pressure drop of the air in passing through the equipment. Alternative mechanisms, which might be advanced to account for this phenomenon are:

1. Wetting Characteristics

The steam alters the wetting characteristics or adhesion forces between the particle and the water droplet.

2. Vapor Diffusion

The diffusion of steam toward the water droplets sweeps dust particles to the water droplet. (*2*)

3. Steam Condensation

The condensation of steam on the particles builds up the particle size so that the particle is more readily impinged on the water droplets.

4. Electrostatic Effects

The presence of steam may result in altered electrostatic effects which assist in collection.

5. Sonic Flocculation

As the steam was injected at sonic or supersonic velocities, the dust particles may have flocculated in the resulting sonic field.

6. Thermal Precipitation

Introduction of steam to the air sets up temperature gradients which may cause

SUMMARY RESULTS

Dust Loss—Talc B
Based on Figures 11-13

Equipment	Semiworks Scale	Laboratory Scale
Cyclone (Operated dry)	1	7
(Operated wet)	2	
Pipeline, Bend or Orifice and Cyclone	3	8
Venturi and Cyclone		
(Water fed in throat)		9
(Water fed in duct)		10
Special Venturi and Cyclone (Water fed in throat or duct)	4	11
Orifice, Special Venturi and Cyclone	5	
Chemical Constr. Corp. Data	6	
Conversion Factor: 1-in. water = 0.157 theoretical hp./(1000 cu.ft./min.)		
Dust Loading = 8 grains/cu.ft.		14

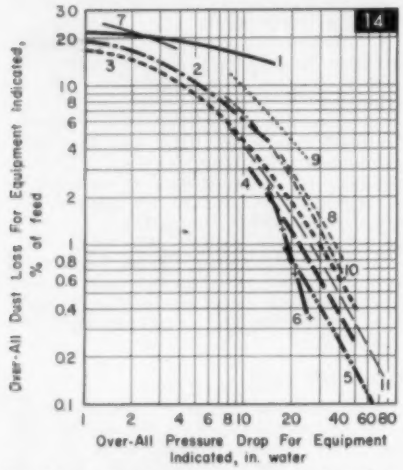


Fig. 14. Comparison of Talc B dust loss data for semiworks and laboratory-scale equipment.

thermal precipitation or migration of the dust particles to the colder water.

It is felt that vapor diffusion and steam condensation are the most likely controlling mechanisms involved, but this statement was not proved. In a single run compressed air, admitted in place of steam through the same nozzle and at the same pressure as the steam, gave no improvement in collection efficiency over simple water scrubbing, thereby disproving the sonic flocculation explanation.

POSITION OF WATER INJECTION

To ascertain the effect of the water injection position on performance, the laboratory-scale special venturi was tested both with water introduced through the four radial throat ports and with water introduced into the duct ahead of the venturi.

The results, shown in Figure 11-B by hollow squares, showed no difference in dust-collection efficiency between the two positions of injections when compared at the same pressure drop. The throat position, however, gave a markedly higher pressure drop at a given air rate as shown in Figure 6-D. Consequently, the introduction of water into the duct ahead of the venturi results in a higher air-handling capacity with a given venturi for a given pressure drop and collection efficiency. In attempting to apply this conclusion to practice, one must choose the size of the approach duct work so that air velocities in this duct will not be so low as to permit the water to channel along the bottom of the duct.

The laboratory-scale simple venturi into which the water was introduced either at one side or at the center of the throat (Figure 11-A) showed a lower collection efficiency at a given pressure drop than any of the other devices tested. While the side inlet gave a much higher pressure drop at a given air rate, there was no significant difference in collection efficiency at the same pressure drop. When the water was introduced into the duct ahead of this venturi, the collection efficiency was markedly better than with the single throat feed and almost equaled that of the special venturi and other contacting devices. This difference in performance between the two feed points for the simple venturi is believed to be due to the resulting water distribution in each case. With the single throat feed, there is a good likelihood of segregation or channeling of air and water in the region of intensive contact. In the case of the upstream introduction point, the water had had a good chance to be distributed across the pipe cross-section, at least at the higher air velocities.

SERIES OPERATION

As the scrubbing action is probably the result of repeated contacting of various parts of the dust-laden gas stream by the water, and as in any specific single unit there is no positive assurance of contacting of all the portions of gas equally, it was felt that operation of two units in series might give better results than operation of either one alone at the same total pressure drop as the two units. To test this idea, the special venturi and the orifice contactors were run in series in the semiworks equipment.

The results, shown in Figure 12, indicate a slight improvement from the series operation. Except for operation at high pressure drops, however, it is felt that series operation has definite limitations. To operate several units in series at a given over-all pressure drop means lowering the gas velocity through each as compared to that through the single unit. If the gas velocity falls too low, serious channeling of air and water through each unit may occur.

MECHANISM OF SCRUBBING

Data shown by hollow triangles in Figure 11-B and recorded for the 1¼-in. pipe in Table 2, represent exploratory runs with a special water nozzle containing fine impinging water jets, previously described. These runs were made at relatively low pressure drop to ascertain in a high-spot fashion the effect of water atomization. Visual observation of the spray from the nozzle indicated it to be considerably finer than the spray from the venturi scrubber or the spray formed by simple contacting in the pipeline itself. In one run, shown by a solid inverted triangle in Figure 11-B, boiling water (steam condensate) was sprayed through this same nozzle with the thought that subsequent flash evaporation would result in a finer spray than would be possible with simple nozzle spraying.

Results of all these runs showed no benefit, however, over what would have been obtained by just dropping the water into the air stream. Though these runs were not elaborate or comprehensive, the

RESULTS

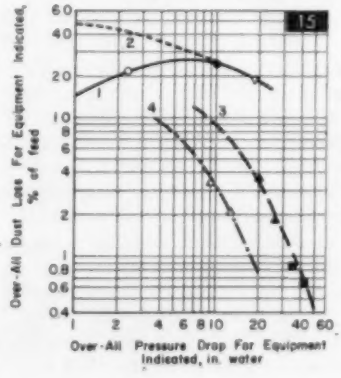
Dust Loss—Talc B

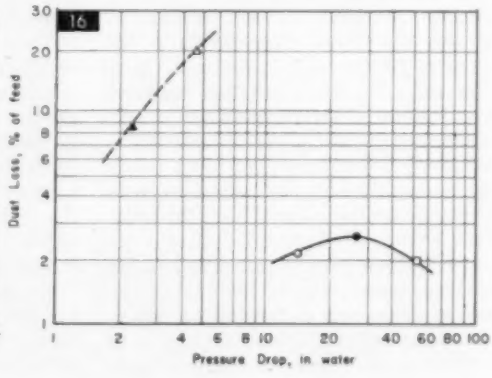
Equipment	Nominal Cyclone Inlet Velocity, ft./sec. 40	80	105
23-in. Cyclone (Operated dry)	○	●	▽
2-1/8-in. Orifice and 23-in. Cyclone	□	■	
2-7/8-in. Vertical S-bend and 23-in. Cyclone	△	▲	
1 Average data for Cyclone (operated dry)			
2 Extrapolated data for Cyclone			
3 Data for scrubbing at Cyclone inlet velocity of 80 ft./sec.			
4 Data for scrubbing at Cyclone inlet velocity of 40 ft./sec.			
Dust Loading = 8 grains/cu.ft.			15

Fig. 15. Ilmenite dust loss data for semiworks scale equipment.

16	Cyclone Inlet Velocity, ft./sec.		
Equipment	35	51	75
8-in. cyclone (operated dry)		▲	△
1-in. contactor and 8-in. cyclone	○	●	□

Fig. 16. Titanium dioxide dust loss data for laboratory-scale equipment.





results would indicate that degree of water atomization, at least in the drop size range involved, is not a major factor in over-all scrubber performance. This result is at first sight surprising because it would naturally be supposed that a large number of small drops would be more efficient for contacting the dust than the same weight of water as a few large drops, both because of the greater projected area of the smaller drops and because of their greater impingement efficiency. Drop size may, of course, in itself be an important individual factor, but changes in drop size apparently are accompanied by changes in other important factors to a compensating extent in so far as dust collection is concerned.

Visual observation made on the pipeline and venturi contactors indicated that marked improvement in water dispersion and atomization took place as the pressure drop approached or exceeded 15 in. water. This is also the region where the collection efficiency increases rapidly as pressure drop is increased (Figure 11).

It is concluded that the controlling factor in scrubber performance must be one associated with pressure drop. Such a factor is turbulence. It is postulated that the scrubber functions by virtue of repeated circulation of the dust-laden gas stream over the suspended droplets, primarily as the result of turbulence. The water droplets are relatively stationary compared to the air and the circulation originates in the turbulent flow of the air within the apparatus. Undoubtedly, water drop size is of importance, but as the degree of atomization is affected by turbulence, drop size and turbulence cannot be distinguished as separate factors in collection. Furthermore, the effect of increased water atomization, even if it could be isolated from the other factors involved in scrubbing, might be much less than would be expected at first sight, because the increased contacting efficiency of small drops as a result of their greater total effective target area may be partly or altogether compensated by the fact that the smaller drops have less inertia, so that there is less circulation of the air past them. The "breakpoint," noted in Figures 11 and 12 (i.e., the point at which a marked reduction in dust loss occurs as pressure drop is increased) at 10 - 15-in. water pressure drop, may be associated with a condition at which water distribution becomes fairly uniform across the gas stream. On this basis it would be a pure coincidence that all the devices tested give the same collection efficiency at the same pressure drop, but it might be expected that there would not be too great a spread, as was indeed the case. Though this study has not been sufficiently comprehensive to prove conclusively the above postulate as to the mechanism by which a scrubber functions, the resulted obtained have led to the formulation of this postulate.

General Discussion

The venturi contactor has been shown to have a small performance advantage over the other units on both laboratory and semiworks scale. This may be due to the fact that intensive contacting takes place over a relatively short space and that good distribution of water and air is obtained. In practice the venturi scrubber would require less power consumption than an orifice or pipeline scrubber for a given collection efficiency. Opposed to this, however, is the greater simplicity, lower space requirement, and greater flexibility of a pipeline or orifice scrubber. An orifice or pipeline scrubber can also be more readily adapted to automatic water recirculation.

Any scrubber is basically capable of giving any desired collection efficiency. The required collection efficiency will determine the power requirement for a given unit. Though not basically limited some commercial units are limited to operating in a specified range of pressure drop by virtue of the specific mechanical design details and consequently are limited to a corresponding specific collection efficiency range. Any full-scale installation should be selected on the basis of an over-all economic comparison at the given desired collection efficiency with a consideration for operating, maintenance, and first cost.

Ekman and Johnstone (*3*) have presented pilot plant data on the removal of sodium sulfate dust and of sulfuric acid mist by means of a venturi scrubber. Their results agree with those of this study in that they show little effect of air and water rate at high collection efficiency. At low collection efficiencies, however, high water loadings and low gas velocities give the best collection efficiency for a given pressure drop. In the case of the sulfate recovery tests, the water loadings at low collection efficiencies are not sufficient to bring the high-temperature gases down to the dewpoint. Consequently, the beneficial effect of increased water loadings at low collection efficiencies may be directly related to the effect of steam injection noted in this study. Insufficient data on gas temperature and composition were presented to determine whether this same explanation might apply to the data on sulfuric acid mist collection.

CONCLUSIONS

1. All comparisons of the performance of dust scrubbing equipment, to be valid, must be made at the same dust loading, i.e., concentration of dust in the entering air stream.

2. Increased dust loadings have little effect on pressure drop but result in higher indicated collection efficiencies, probably because of increased initial agglomeration of the dust particles. With dusts that are difficult to disperse (deflocculate), there was an advantage on collection efficiency in these tests in using high water rates rather than high gas rates. For a given pressure drop high water rates go with low gas rates, which reduces the dispersing action of the moving gas.

3. When compared at the same gas power consumption, all the scrubbers give substantially the same degree of collection of a given *dispersed* dust, regardless of the mechanism involved and regardless of whether the pressure drop is obtained by high gas flow rates or high water flow rates. The collection efficiency increases as the pressure drop increases, the increase being especially rapid for pressure drops over 10-in. water.

4. Small-scale scrubber units give results which, although slightly conservative (i.e., lower collection efficiency), are of the same order of magnitude as those obtained with large units operated at the same conditions with the same dust.

5. The method or position for introducing water into a scrubber is important only in so far as it prevents channeling of gas and water.

6. Operation of units in series results in slightly greater collection efficiency than operation of a single unit at the same total pressure drop as that across the units in series.

7. The injection of an amount of steam corresponding to 2 or 3 times that required for saturation results in a marked increase in dust collection efficiency. For application to high-temperature gases, this is believed to be an indication that adding sufficient water to cool the gases to or below the dewpoint will result in marked benefits in collection efficiency.

8. The predominant mechanism which results in deposition of dust on the water drops in a scrubber is believed to be that of turbulent circulation of dust-laden gas over the water drops. Degree of water atomization is not a controlling factor in over-all performance.

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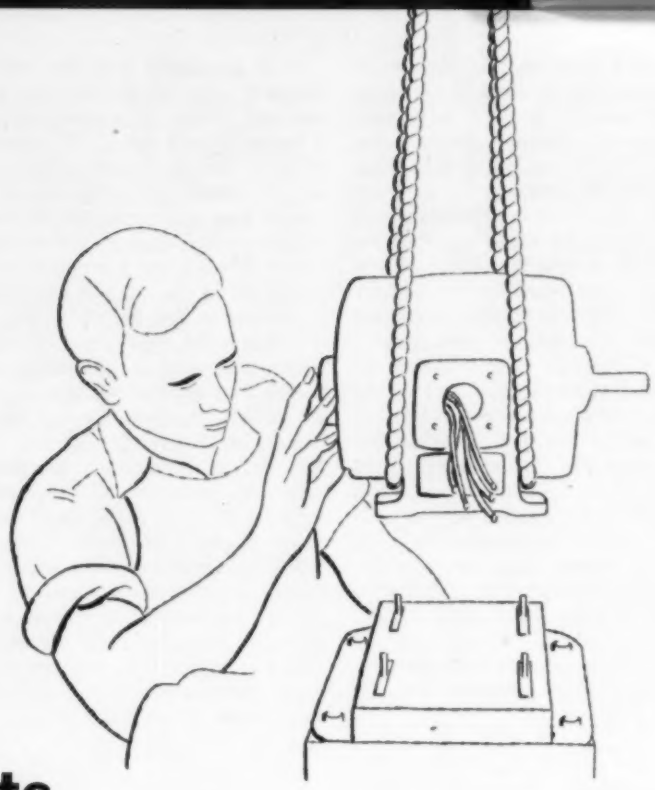
Presented at A.I.Ch.E. 46th annual meeting, St. Louis, Mo.

work. This method is slightly more complicated than that method which



estimating maintenance costs for new plants

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In order to improve on the accuracy of present methods of estimating repair costs, a new attack has been made on this problem. Basically, it is an offshoot of the method which uses a percentage of the investment as an estimate of repair costs. This new approach should prove to be helpful in estimating work.

As generally understood, estimating manufacturing costs for new plants presents some difficulties although help has come from the many articles and books which have been written on the subject within the last few years. However, this estimation of costs is far from being an exact science. There are still many areas where more data need to be made available, specifically the area of repair costs. A certain amount of work has already been done on this subject so that now at least four methods are available. They can be described briefly as follows:

1. By consulting company records of the same or similar operations.

One should look into this source first because the data are usually the most accurate available. However, when the operations to be estimated are completely different from existing ones—a common occurrence—then another approach must be used.

2. By using a percentage of investment costs.

Happel, Aries, and Borns (1) say: "For general chemical and petroleum processing plants, the annual maintenance expense (labor and materials) ranges from 2 to 3% of the equipment costs for mild service and simple equipment to 7 or 10% for severe conditions. A good average is 4% of equipment cost annually . . . "

This is a good basis to start with, especially for a large plant since it involves no extra estimating work. One usually has the investment, and it is simply a matter of multiplying this investment by a factor. However, since the factor range from 2% to 10% is wide, it is difficult to pinpoint the exact percentage to use.

3. By estimating repair costs for each piece of equipment in the plant (2).

As there are usually many equipment items in a plant, estimating the cost by this method is a longer process than using a per cent of investment. For the smaller jobs, say under $100,000 where the unknown equipment items are reasonably small, this method works out rather well and is more accurate than the investment percentage method. A large investment requires a different approach because of the estimating time needed and the unknown equipment included in the contingency for which you would not have a factor.

4. By relating repair labor man-hours and power requirements. (kilowatt hours of electricity) (3).

Because of the good correlation between repairs and power consumed, this relationship has been successfully used to forecast repair costs at existing plants. However, as yet it has not been applied to new plants.

Greater estimating accuracy can be obtained by employing a variation of the per cent of the investment approach. Previously only one percentage has been applied against the entire plant investment. However, if the plant investment is broken down into various major unit operations, such as evaporation, drying, burning, etc., then the repairs can be estimated much more accurately—probably within ±25%. Such accuracy is good enough for preliminary study

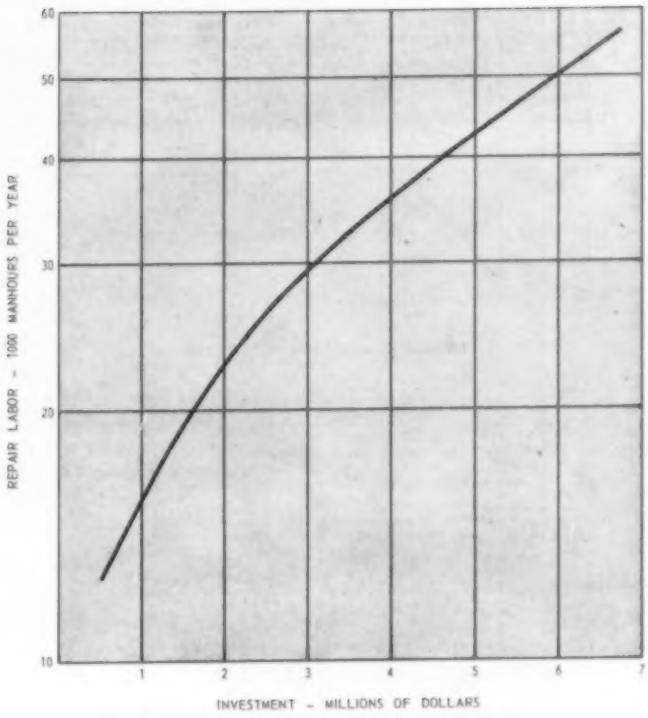
work. This method is slightly more complicated than that method which uses only one investment, because it requires some breakdown of the investment into various operations. However, this is easy to do if the investment has been estimated with some degree of detail and accuracy. A plant can usually be split into a small number of large unit operations. For instance, a chlorine plant might have been broken down into these operations: brine wells, brine treatment, electrolysis, gas compression, liquefaction, caustic evaporation, product loading, and utilities. The investment would be estimated for each operation, and the repair cost for each operation would be found by use of graphs of repair costs vs. investment.

Such graphs have been developed for the following operations.

1. drying and burning
2. evaporation
3. grinding and pulverizing
4. reactions
5. pumping
6. treating
7. materials handling
8. utilities
9. summary

In the plots shown here the investment includes all equipment, foundations, structural supports, piping, electrical work, and buildings connected with that particular operation. The investment has been adjusted to the present-day replacement value. Repair costs have been divided into labor man-hours and repair material dollars. The repair material is shown as dollars per man-hour of repair labor and is estimated from the repair man-hours. By the use of man-hours the problem of wage rates being different in one locality as compared to the next and from one period of time to the next is avoided. The repair material dollars can be adjusted for inflation by using the *Engineering News Record Index*, which has been found to be quite successful, or some similar index such as Marshall-Stevens. These graphs are based on *E.N.R. Index* of 600. The investment which is based on *E.N.R.* of 600 will also need periodic adjustment to take into account the ever-rising construction costs.

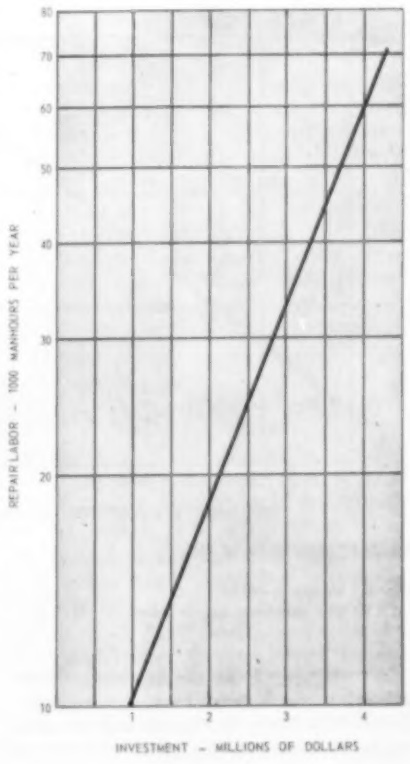
On these graphs is plotted millions of dollars of investment vs. thousand man-hours of repair labor per year. Also depicted are the dollars of repair material per man-hour of repair labor so that the total repair costs may be easily obtained. Any discussion of this type of data should give some idea of the reliability because of the limited number of points available. None of the curves has been extrapolated because of the uncertainty in so doing.



DRYING & BURNING

Fig. 1. Repair material —$1.20 per manhour repair labor.

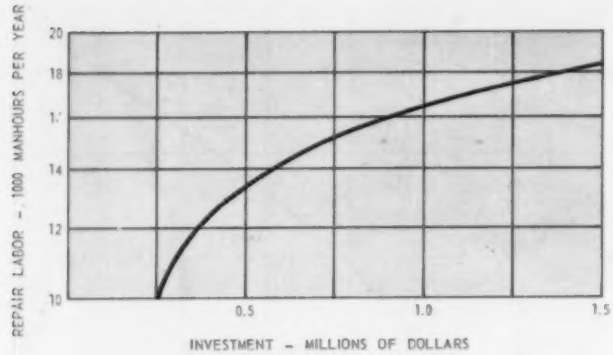
This operation (Figure 1) includes those operating units, the predominant equipment of which are kilns of one sort or another—rotary or vertical, lined or unlined. The investment range is wide and runs from $500,000 to over $6,500,000. This curve can be reliably used for drying and burning operations of the type, such as lime or cement kilns. However, it does not include kiln relining costs which would be an additional 25 or 30%.



EVAPORATION

Fig. 2. Repair material —$1.33 per manhour repair labor.

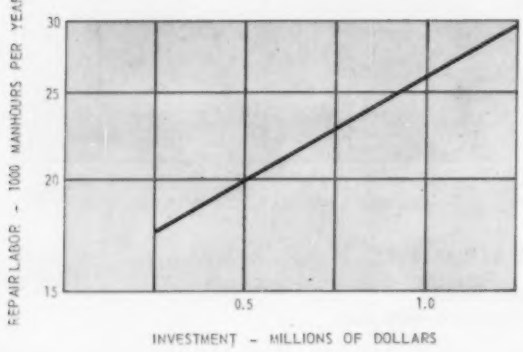
This curve (see Figure 2) is only for forced circulation evaporators; hence its use is somewhat limited. However, the curve is based on several points with the investment running from $1,000,000 to $4,300,000.



GRINDING & PULVERIZING

Fig. 3. Repair material $1.42 per manhour repair labor.

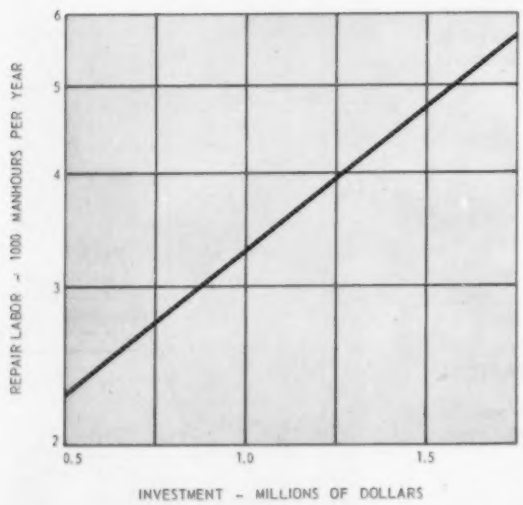
The curve in Figure 3 is based on only four points, but it offers some idea of the order of magnitude of this type of operation. The investment in this case is from $250,000 to $1,500,000.



REACTIONS

Fig. 4. Repair material —$1.75 per manhour repair labor.

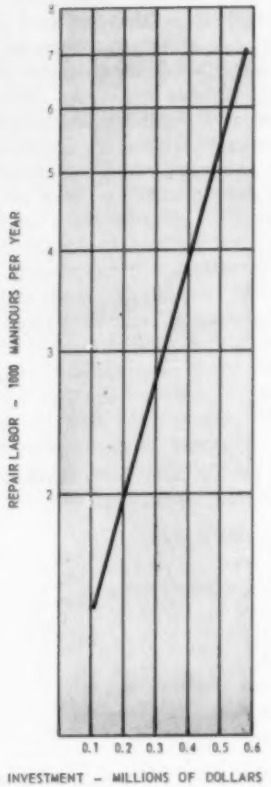
Figure 4 unfortunately does not cover enough territory as it ranges from $250,000 to $1,250,000. It is based primarily on relatively large-scale organic operations.



PUMPING (Flow of Fluids)

Fig. 5. Repair material —$1.12 per manhour repair labor.

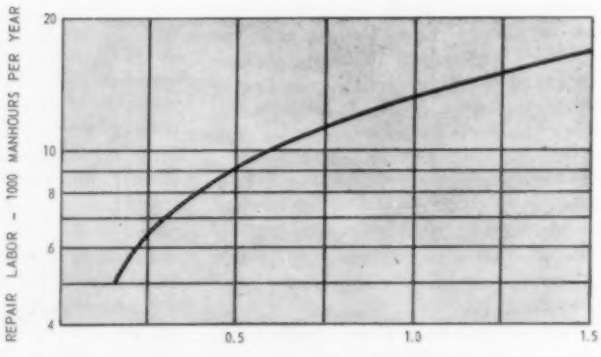
This refers to a large-scale operation, such as pumping process water or brine. The investment is from $500,000 to $1,750,000, and the curve (Figure 5) is reasonably reliable.



TREATING (Fluid Flow and Storage)

Fig. 6. Repair material —$1.60 per manhour repair labor.

This operation, shown in Figure 6, includes tankage and pumps, and is based on a relatively few number of points.



MATERIALS HANDLING

Fig. 7. Repair material —$1.70 per manhour repair labor.

Included here are cranes and conveyors for large operations such as coal handling. This curve, Figure 7, is also based on a relatively small sample and is somewhat unreliable.

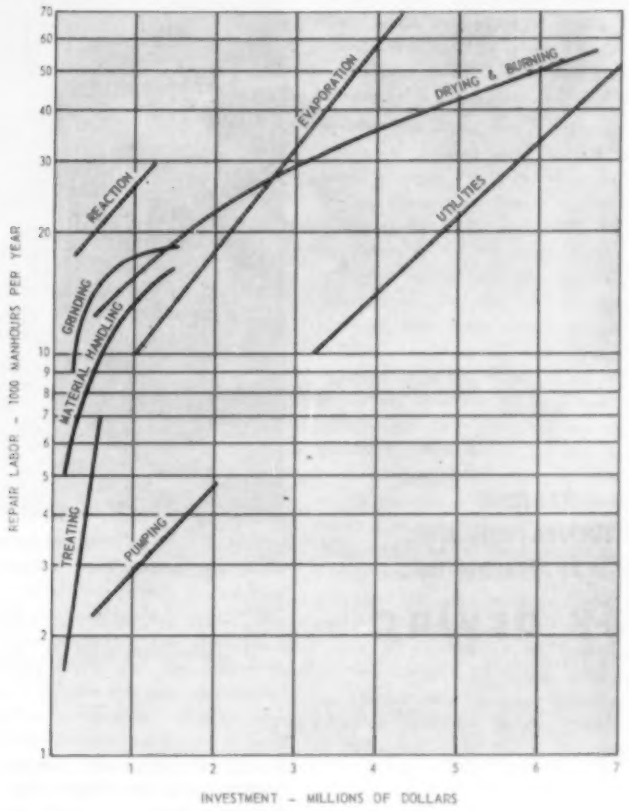


Fig. 9.

SUMMARY

The summary (Figure 9) shows all curves, and the wide range indicates why the approach given here is more accurate than when a single percentage of the investment is used. For instance, if one assumes an investment of one million dollars, the possible range is from 2,900 to 26,000 man-hours per year for pumping as compared to reactions. The possible error is tenfold though it is unlikely, especially if the estimator is capable of discretion.

This is the extent of the work to date on this approach, and in conclusion the following points can be considered.

1. Accompanying graphs are incomplete in that number of points should be increased substantially to test further the validity of the curves. Curves should be extended in both directions to increase their value.
2. The range of operations covered should be increased to include distillation, gas absorption, filtration, refrigeration, heat transfer, and other operations.
3. The possibility of developing repair man-hour vs. power-utilized (i.e., equivalent kilowatt hours) curves should be examined. The work of Pierce (*3*) indicated that a good correlation exists which can be used in maintenance scheduling. This would probably be a more accurate approach than the investment one presented here if it could be successfully developed. However, there are two major questions to be answered in developing this method: (1) How accurately can the connected load, i.e., motors and steam turbines be estimated? and (2) what is the relationship between the connected load and the actual power consumption?

UTILITIES (Power Generation)

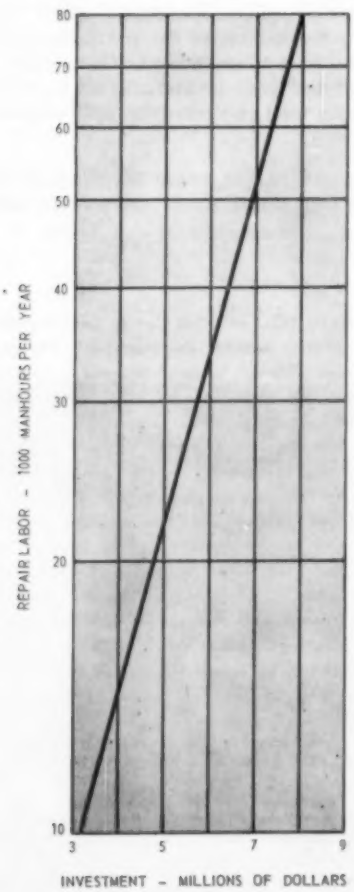


Fig. 8. Repair material —$1.48 per manhour repair labor.

These items seem to fall into a category by themselves since the repair costs are so much lower than they are for normal process operations. The curve is based on fairly large combination steam and electric generation plants. (Note that the investment runs from $3,200,000 to $8,000,000.) (See Figure 8.)

Literature Cited

1. Happel, J., R. S. Aries, and W. J. Borns, "Equipment and other Items in Engineering Economics," *Chem. Eng.* (December, 1946).
2. Leonard, Jackson D., "What Does Maintenance Cost?" *Chem. Eng.* (September, 1951).
3. Pierce, D. E., "Common Denominator for Repair Costs," *Chem. Eng. Progress* (March, 1948).

Presented at the annual one-day meeting of the New York Section, October 13, 1954.

FACTORS AFFECTING GAS RECIRCULATION AND PARTICLE EXPANSION IN spray drying

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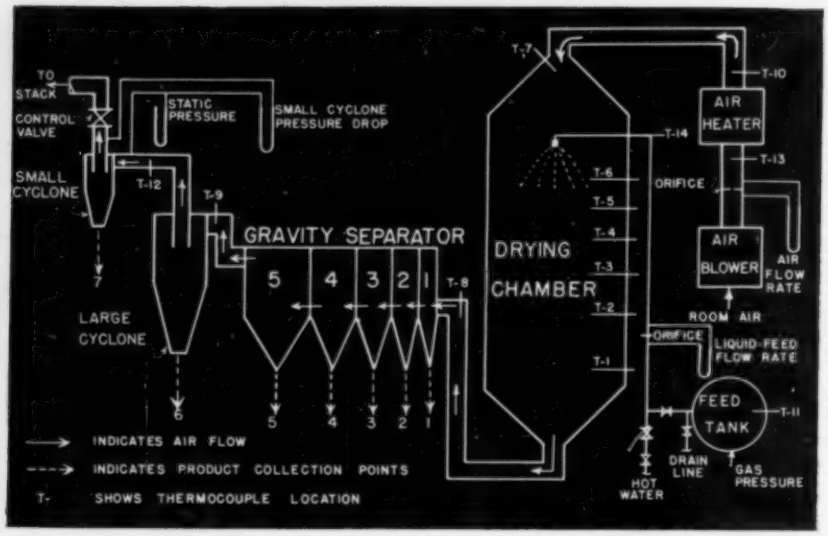

Fig. 1. Schematic diagram of experimental equipment.

A vertical cylindrical cocurrent-flow spray dryer and a unique product-collection system were developed for experimental studies of spray drying by use of an aqueous ammonium sulfate feed solution. All possible operating variables were considered and reduced to those which directly and independently affect the drying operation. These are the size and size distribution of the spray droplets, the gas temperature in the drying zone, and the feed concentration. The principal product property determined was the ratio of the final to the original particle diameter, which was found to increase with both feed concentration and original particle diameter.

Gas recirculation in the drying chamber occurred to the extent of about three fourths of complete mixing as indicated by vertical drying zone temperature and humidity distributions.

Spray drying has become an important operation in the preparation of a wide variety of finished products, but it is not fundamentally understood. This investigation was undertaken to study two distinct phases of spray drying which have not received much attention in the past, namely the recirculation of gas within the drying chamber and the relationship between final particle diameter and original spray-droplet diameter.

The problem of atomization was separated from the drying problem proper in the experimental investigation by the use of a set of pressure spray nozzles previously calibrated by Turner and Moulton (*14*), who correlated drop size and size distribution with nozzle diameter, feed viscosity, surface tension, and flow rate. Thus, indirect variables could be combined into those factors which directly and independently affect the spray drying operation, namely size and size distribution of the spray, feed concentration, and drying zone gas temperature. Each of these factors could be either measured directly or calculated from factors which could be measured.

Experimental

A schematic diagram of the experimental equipment is given in Figure 1, and drying-chamber details are given in Figure 2.

All temperature measurements were made with thermocouples by use of standard techniques. The six thermowells in the drying zone were protected from direct contact with the wet spray by inclined troughed trays. This procedure prevented the lowering of the thermowell temperature toward the wet-bulb temperature of the gas and apparently introduced no adverse effects. The gas temperature was calculated from the thermocouple readings by the application of two corrections: the error caused by conduction of heat out of the thermowell was calculated by the method of Rizika and Rohsenow (*13*), and that due to heat transfer by radiation between the thermowell and surfaces of different temperatures was calculated by the method of McAdams (*8*). The maximum correction to any reading was 30° F.

Humidities were measured at four points in the drying chamber by bleeding samples past a wet- and dry-bulb thermometer pair, a technique described in detail by Chamberlain and Rehm (*2*), who showed that the humidity values so obtained have an average error of about 9%.

In order to study the variation in product properties with particle size, a collection system was constructed which separates the powdered product into its various size ranges as it leaves the drying chamber (Figure 3). The larger par-

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settled on the trays protecting the thermowells

The observed vertical temperature and

feed. By neglecting deceleration of the

ticles were collected in a series of five gravity settling chambers, the smallest particles then being collected in two cyclones, built according to a standard design for which performance data were available (*11*). The large cyclone was 12 in. in diam. and 24 in. high, with a 3- by 6-in. rectangular tangential inlet and a 6-in.-diam. outlet. The small-cyclone dimensions were 41.7% of those of the large one. The moist air and product travel through the chambers in series, the largest particles falling out in the first and smallest one, and so on. Each chamber, fitted with a hopper and a collection box on the bottom, was 18 in. high (A_s) and 17.5 in. long (C_s) but varied in width, B_s, from 2 to 17.3 in. A more detailed discussion of the experimental equipment is given elsewhere (*1*).

Aqueous ammonium sulfate solutions were spray dried in this investigation because they have many desirable physical properties and the results obtained should be representative of those which would be obtained from spray drying a large number of inorganic salts. In order to avoid extrapolating the range of physical properties upon which Turner's spray-size correlating equations are based, the surface tension of the feed solutions was lowered to a definite value in the range of 25 to 35 dynes/cm. This was done by the addition of about 0.02% of a 60% solution of a triethylammonium alkyl aryl sulfonate. The surface tension of such solutions has been correlated with salt and detergent concentrations at various temperatures by Wittkopf (*17*). The addition of such small quantities of detergent was assumed to have a negligible effect on the density and viscosity of the feed solutions. The density was obtained from Lange (*5*), the viscosity from Washburn (*16*).

The liquid feed temperature at the nozzle was maintained as close as possible to the wet-bulb temperature of the air into which it was sprayed, in order to prevent appreciable temperature change of the solution during droplet formation from the thin liquid sheet issuing from the nozzle. This procedure also eliminated sensible heat effects during the initial drying period.

Thirty runs were made in this investigation; ten of them, with a feed containing no ammonium sulfate, served as a basis of comparison with theoretical equations. Ammonium sulfate concentrations from 0.1 to 0.7 g. salt/g. water were used at feed rates varying from 0.7 to 5.3 g./sec. The air flow rate was kept between 275 and 350 lb./hr., and the inlet air temperature between 750 and 950° F. The drying chamber and insulation were initially brought to their steady-state temperatures by a preheating period followed by a period of spraying hot tap water at the same rate as the water in the feed would be sprayed. Fluctuation of temperatures during the feed-spraying period was thus kept within 5° F.; this fluctuation was attributable to variation of the voltage applied to the air heater elements.

All temperatures and humidities were measured at three or four equally spaced time intervals during the feed-spraying period, the average value being used in the calculations.

For each spray drying run the weight of powder collected in each box was determined, and representative samples for moisture- and bulk-density determinations were taken from each box immediately after the box was removed from the collector. The samples were weighed in 12-ml. bottles after the powder had been gently diced with a spatula to eliminate gross void spaces. This arbitrary procedure was selected as the one which would give the most realistic and reproducible bulk-density data. The samples were dried to constant weight and the moisture contents calculated.

The runs made in this investigation covered completely the possible range of liquid feed variables, ϵ, $\overline{D_{po}}$, and $\overline{\sigma}$, for the only two calibrated stainless steel nozzles which functioned properly within the evaporative capacity of the equipment. These nozzles had orifice diameters of 0.723 and 1.073 mm.; periodic measurements of the nozzle orifice diameters indicated no corrosion during their use. The volume-mean diameter of the spray droplets obtained with these nozzles ranged from 65 to 120μ on various runs. The logarithmic standard deviation, $\overline{\sigma}$, was 0.155 for the small nozzle and 0.177 for the large nozzle.

Static electricity presented one of the major difficulties encountered in the experimental work. Magnetic vibrators were installed on the drying chamber and gravity collector to help retard the adhesion of the particles to the walls, due to loss of the static charge picked up during spraying (*6*) and during passage through the ducts (*10*); the equipment was thoroughly washed between runs.

From 45 to 70% of the ammonium sulfate fed was accumulated in the collection system, the powder which was not collected being retained in the drying chamber. About one third of that retained in the drying chamber had

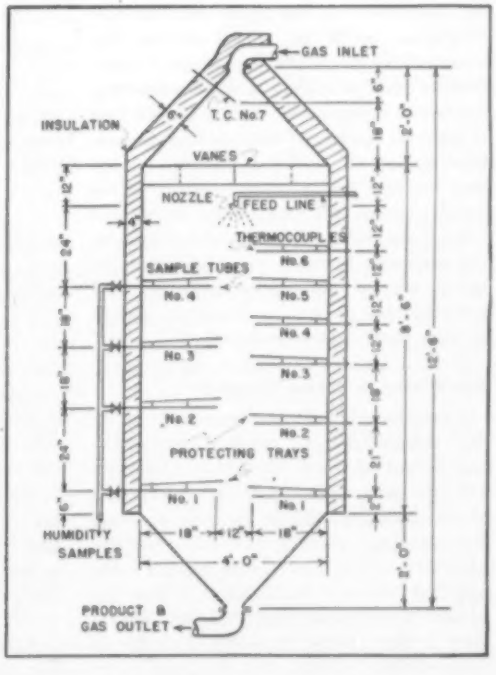

Fig. 2. Drying chamber details.

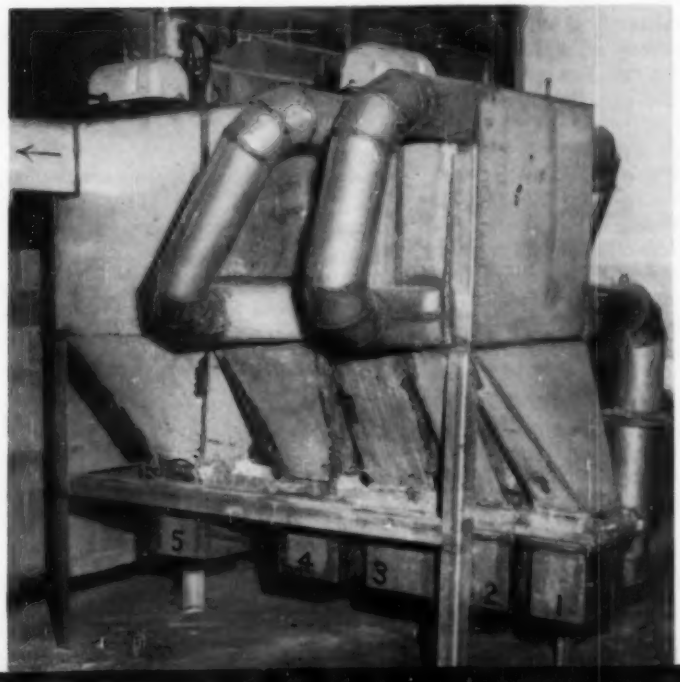

Fig. 3. Photograph of gravity separator.

can be approximately corrected for the

complete mixing was achieved.

cyclones was assumed to be all that

settled on the trays protecting the thermowells and moisture-content-sampling tubes. The remainder was on the surface of the lower cone, and remained there because of effects of static electricity which the vibrator could not overcome. Microscopic examination on a typical run showed, however, that the powder retained in the dryer cone was very nearly of the same size and size distribution as that collected; the difference in average diameter between that collected in the dryer cone and in the separator and cyclones was only 7% for run 30.

From 0.3 to 4.0% of the ammonium sulfate fed passed through the entire collection system without being collected. (This quantity was measured by bleeding samples of the exit gas through a glass-wool-packed tube and a wet-test meter.) Microscopic analysis of the powder in the exit gas stream showed it to be almost entirely composed of very small fragments of larger particles which had evidently been broken during passage through the equipment. This small amount of particle breakage would introduce little error into the interpretation of the results, and was accordingly ignored.

Thus, while the amount of product collected was a smaller fraction of the total than would be desirable, the interpretation of the data should nevertheless give reliable conclusions.

Heat and material balances were made for all runs. The total weight of feed used during each run as measured by loss in weight of the carboy agreed within 2 per cent in each case with that calculated from the flow rate and duration of the run. The feed rate indicated by the manometer was used in all calculations. For the drying-chamber energy balance, inlet- and exit-gas temperatures were calculated from the nearest external thermocouple reading by correction for heat losses from the pipe between the thermowells and the drying chamber. The heat given up in the drying chamber was accounted for as (1) enthalpy change of water between liquid at T_o and exit vapor temperature (2) heat of crystallization (5), (3) sensible heat of the dried powder, (4) heat loss from the insulated portions of the drying chamber, and (5) heat loss from the uninsulated portions of the drying chamber. The average error in this heat balance was under 3%, the maximum error for any run being 10%. As these calculations involved most of the experimentally measured quantities, they serve to corroborate the over-all accuracy of the experimental work.

Gas Mixing in Drying Chamber

Considerable vertical gas mixing or recirculation should result from the introduction of the high-velocity inlet-air stream into the relatively wide and short drying chamber as well as from the localized cooling occurring in the chamber. This result was qualitatively verified during this investigation by visual observations made through a window in the drying chamber. Powder in large concentrations was observed above the nozzle during the runs, and some powder collected during each run on small ledges located above the nozzle.

The observed vertical temperature and humidity distributions for the water-spray runs were used to determine quantitatively the extent of vertical gas mixing by comparison with the theoretical distributions for extreme degrees of mixing.

Complete gas mixing in the chamber would result in values of humidity and temperature throughout the chamber being uniform at the values of the exit air. The temperature and humidity distributions for no mixing are more difficult to calculate. An exact mathematical treatment of this case would be extremely cumbersome and is not necessary for the present purpose. A satisfactory approximation results from the following three simplifying assumptions: (1) gas temperature is constant at the average experimental value, (2) the spray is uniformly distributed over the entire chamber cross section, and (3) deceleration to terminal velocity occurs while the particle diameter remains constant at its initial value. These assumptions are used in the simplified theoretical treatment which follows; they introduce varying errors in the calculations, depending upon the size of droplets considered, but in any case the errors are confined to the temperature and humidity distributions close to the nozzle and become negligible at distances beyond about 2 ft. from the nozzle.

Approximate vertical temperature and humidity distributions which would exist without any gas mixing were calculated in the following manner for runs made with no ammonium sulfate in the feed. By neglecting deceleration of the particles formed during atomization and using Stokes' law, one may write:

$$\frac{dl}{d\theta} = \frac{g_c D_p^2 \rho_o}{18\,\mu_g} + u_g \qquad (1)$$

This equation may be combined with the basic drying-rate equation,

$$-\frac{dm_p}{d\theta} = \frac{\pi D_p^2 h (t - T)}{\lambda} \qquad (2)$$

The natural-convection heat transfer coefficient,

$$h = \frac{2\,k_f}{D_p} \qquad (3)$$

has been shown by Marshall and Seltzer (7) to be applicable with little error for the small particles involved in this investigation. Combining the foregoing equations, one has

$$dl = -\frac{\lambda \rho_o D_p}{4\,k_f (t - T)} \left[\frac{g_c D_p^2 \rho_o}{18\,\mu_g} + u_g \right] dD_p \qquad (4)$$

Equation (4) can be integrated between the distance limits of zero at the nozzle and l at any point in the drying chamber if gas temperature is considered constant at the average experimental value. The resulting equation,

$$l = \frac{\lambda \rho_o}{8\,k_f (t - T)} \left[\left(\frac{g_c \rho_o}{36\,\mu_g} \right) (D_{po}^4 - D_p^4) + u_g (D_{po}^2 - D_p^2) \right] \qquad (5)$$

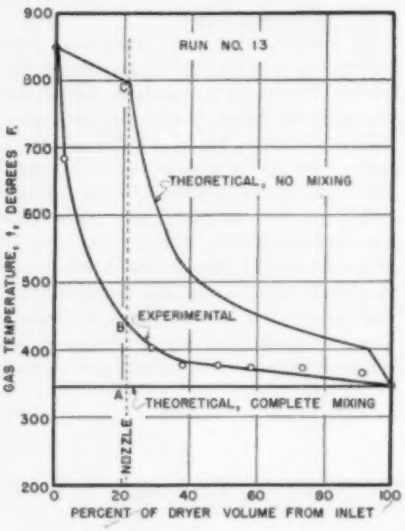

Fig. 4. Comparison of experimental and theoretical temperature distributions in drying chamber.

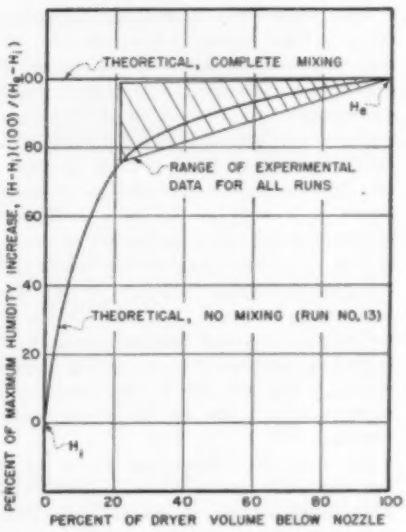
THEORETICAL, COMPLETE MIXING
RANGE OF EXPERIMENTAL DATA FOR ALL RUNS
THEORETICAL, NO MIXING (RUN NO. 13)
PERCENT OF MAXIMUM HUMIDITY INCREASE, (H-H$_i$)(100)/(H$_s$-H$_i$)
PERCENT OF DRYER VOLUME BELOW NOZZLE

Fig. 5. Comparison of experimental and theoretical vertical humidity distribution in drying chamber.

can be approximately corrected for the additional distance traveled by a particle during deceleration by integration of the unsteady-state differential equation for the initial particle motion if constant particle diameter is assumed. The corrective term,

$$\frac{(u_o - u_t) D_{po}^2 \rho_o}{18 \mu_g}$$

was added to the path lengths calculated from Equation (5). The initial vertical particle velocity, u_o, is obtained from the following relation, in which the diameter of the air core in the nozzle orifice, D_a, is obtained from the correlation of Doumas and Laster (*4*):

$$u_o = \frac{4 w \rho_o \cos \phi}{\pi (D_n^2 - D_a^2)} \qquad (6)$$

To facilitate the use of the preceding equations, the original spray-droplet-size distribution for each water-spray run was divided into sixteen convenient size groups. The fractional reduction in diameter for each of these groups was then obtained from Equation (5), corrected for deceleration, at various distances from the nozzle. The cumulative evaporation occurring up to that point was then determined from the loss in weight of all size groups. From this result, theoretical temperature and humidity distributions for no vertical mixing (and for no horizontal gradient, for example uniform spray over the entire chamber cross-section) were calculated.

When the experimental vertical temperature distribution for run 13 is compared with the theoretical vertical temperature distributions for the two extreme degrees of mixing, it is clear from Figure 4 that the experimental temperature is approximately the same fractional distance between the two theoretical temperatures over the entire drying zone. Therefore the fractional approach to complete mixing, defined as $\overline{BC}/\overline{AC}$ as shown on Figure 4, was calculated only at the location of the nozzle. It should be noted that the calculation of the degree of mixing at the nozzle location is affected by heat-loss calculations only and is independent of any assumptions made in deriving Equation (5).

The fractional approach to complete mixing was calculated for all runs in the foregoing manner. Results varied from 0.68 to 0.86 and averaged 0.785. Statistical analysis of these values showed no dependence on liquid feed rate and a slight but not conclusive tendency to increase with increasing air flow rate.

These data therefore show that vertical gas mixing occurred to such an extent that about three quarters of complete mixing was achieved.

A general comparison of the experimental and theoretical vertical humidity distributions is given in Figure 5. The spread of the data together with the close approach of the theoretical humidity distributions for no mixing and for complete mixing over the part of the drying zone for which data were taken precludes any but a statistical analysis of the situation.

Accordingly, linear extrapolations to the nozzle position of the best straight line through the experimental data were made for each run, and the fractional approach of the intercept from the inlet humidity to the exit humidity was taken as a measure of the extent of complete mixing in the drying chamber. The average approach of the intercept to the exit humidity for all thirty runs was 77.2%. This figure supports very well the average extent of complete mixing calculated from temperature gradients of 78.5%.

Mixing of such magnitude is important for two major reasons: the nearly constant (and lower than would otherwise be expected) gas temperatures in the drying zone and the greater spread of particle residence times (particularly for small particles) in the chamber than would otherwise be expected.

The mixing is believed to be due principally to two factors, the jet effect of the high-velocity inlet-air stream and the localized volume contractions caused by cooling from the spray and from heat losses through the chamber walls. Inasmuch as a smaller but still appreciable degree of mixing was indicated even without the spray, both factors are believed to be significant. Although the magnitude of the gas recirculation determined in this investigation is of course limited to the range of variables covered by this study and by the shape of the drying chamber, the effect is probably of qualitative applicability to nearly all spray drying operations.

Particle Expansion

The original diameter of all spray droplets was obtained with Turner's equations, and the collection in the separator was used to determine the final particle diameter. The results were calculated and correlated as the particle expansion ratio, r, defined for each particle as

$$r = \frac{D_{pf}}{D_{po}} \qquad (7)$$

According to previous investigators (*11*), the cyclones will collect all product of the size expected to enter them; therefore in this investigation the theoretical quantity collected by the cyclones was assumed to be all that could pass through the gravity separator.

The theoretical performance of the gravity settling chambers was compared to an ideal chamber with "plug" flow of gas, into which the powder entered uniformly mixed with the gas without discrimination as to particle size. For such an ideal chamber, the probability of collection, η, of a given-sized particle in a given chamber is calculated by use of Equation (8):

$$\eta \text{ ideal} = \frac{(\text{residence time in chamber})}{(\text{time to fall from top of chamber})} = \frac{u_t C_s}{A_s u_g} \qquad (8)$$

(A calculated value of η greater than unity is meaningless and should be treated as though it were unity.)

The probability of collection of a particle in the actual chambers would be greater than that given by Equation (8), primarily because of a longer residence time due to recirculation within the collection chamber. Other factors such as impingement of particles on the wall opposite the inlet might cause further deviations. A coefficient of performance, k, as defined by Equation (9), was introduced to account for such deviations in performance between the actual and ideal separating chambers:

$$\eta = \frac{k u_t C_s}{A_s u_g} \qquad (9)$$

The coefficient of performance would certainly vary with the dimensions of the chamber and would probably also be a function of such other factors as airflow rate and particle properties. It has to be experimentally determined under conditions similar to those for which it is to be applied.

Equation (9) can be modified to a more useful form by substitution. The particles can be assumed to obey Stokes' law with a maximum error of 10%, and thus the particle-settling velocity will be

$$u_t = \frac{m_{pf} g_c}{3 \pi D_{pf} \mu_g} \qquad (10)$$

From the definition of an ideal chamber, one may write,

$$u_g = \frac{W}{\rho_g B_s A_s} \qquad (11)$$

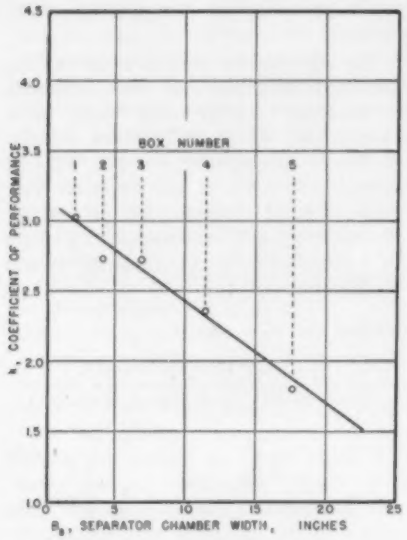

Fig. 6. Gravity separator calibration chart.

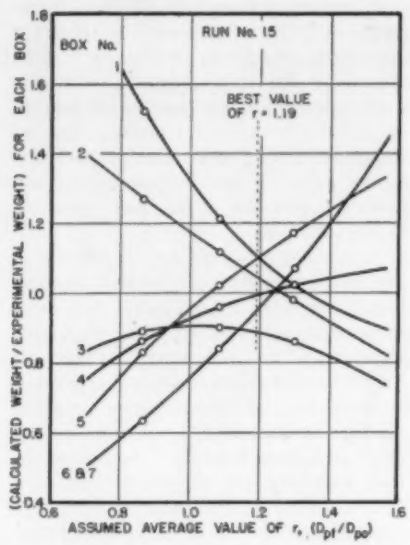

Fig. 7. Sample determination of best value of r.

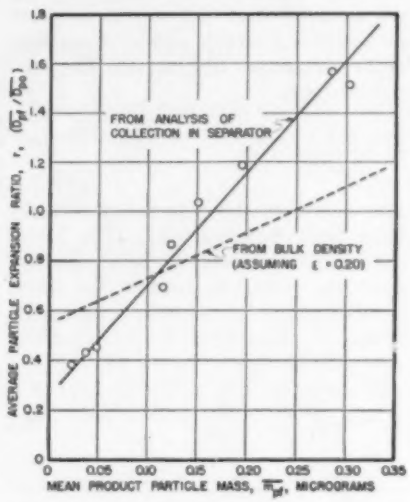
FROM ANALYSIS OF COLLECTION IN SEPARATOR
FROM BULK DENSITY (ASSUMING ε = 0.20)
AVERAGE PARTICLE EXPANSION RATIO, r, $(\overline{D}_{pf}/\overline{D}_{po})$
MEAN PRODUCT PARTICLE MASS, $\overline{m}_{pf}$, MICROGRAMS

Fig. 8. Correlation of particle expansion ratio.

Substitution of Equations (10) and (11) in Equation (9) gives

$$\frac{m_{pf}}{D_{pf}} = \frac{3\pi\eta\mu_g W}{g_c B_s C_s k \rho_g} \tag{12}$$

But assuming essentially complete drying and utilizing the definition of particle-expansion ratio, r, one can also write,

$$\frac{m_{pf}}{D_{pf}} = \frac{\pi D_{po}^2 c \rho_o}{6 r(1+c)} \tag{13}$$

Equating the last two expressions and rearranging give

$$\frac{D_{po}^2}{r\eta} = \frac{18\mu_g W(1+c)}{k c \rho_o g_c B_s C_s \rho_g} \tag{14}$$

All quantities in Equation (14) were measured or could be calculated from measured quantities except k, r, and η. The coefficient of performance, k, was experimentally determined by introducing small glass beads with microscopically measured size distribution into the drying chamber by air aspiration through the liquid-feed line and measuring the weight collected in each chamber. Two calibration runs were made, each at the same average air velocity used in all spray drying runs. The two runs were made at widely different rates of introduction of glass beads. The weights collected in each box agreed for the two runs within 0.2%, showing excellent reproducibility and independence of rate of solid feed for the entire collection system.

Equation (14) was used to calculate the coefficient of performance of the separators from the results of calibration. For this case the terms r and $(c/1+c)$ are unity, and the subscripts o and f are interchangeable. With various values assumed for k, collection effi-

Table 1.—Sample Trial Calculation of r, Run 15

Group Avg. D_{po} (μ)	Basis: 100 lb. Powder Collected — Per Cent Collection Efficiencies of Boxes from Eq. (14) 100η 1	2	3	4	5	Total Wt. in Size Group (lb.)	Trial Value of $r = 1.084$ — Calculated Collected Weights in Boxes 1	2	3	4	5	6–7
15	0.3	0.5	0.8	1.3	1.7	0.4	0.00	0.00	0.00	0.00	0.00	0.40
30	1.0	2.0	3.3	5.1	6.8	1.4	0.01	0.03	0.05	0.07	0.08	1.16
50	2.7	6.1	9.2	14.1	18.9	11.5	0.31	0.68	0.97	1.34	1.55	6.65
70	5.4	10.9	18.0	27.6	37.0	7.6	0.41	0.78	1.16	1.45	1.41	2.39
80	7.0	14.2	23.6	36.0	48.3	8.8	0.62	1.16	1.66	1.93	1.66	1.77
90	8.9	18.0	29.8	45.5	61.1	10.2	0.90	1.67	2.28	2.44	1.78	1.13
100	10.9	22.2	36.8	56.2	75.4	9.8	1.07	1.94	2.50	2.41	1.42	0.46
110	13.2	27.0	44.5	68.0	91.3	9.7	1.28	2.27	2.74	2.32	1.00	0.09
120	15.8	32.0	53.0	80.9	100+	8.3	1.31	2.24	2.51	1.81	0.43	
130	18.5	37.6	62.1	95.0	100+	7.3	1.35	2.23	2.31	1.33	0.08	
140	20.4	43.7	71.8	100+	100+	6.3	1.28	2.19	2.03	0.80		
160	28.0	57.0	94.0	100+	100+	11.0	3.08	4.51	3.20	0.21		
190	39.5	80.4	100+	100+	100+	5.4	2.14	2.62	0.64			
220	52.8	100+	100+	100+	100+	1.7	0.90	0.80				
250	68.3	100+	100+	100+	100+	0.6	0.41	0.19				
						W_o = Total calculated weight	100.0	15.07	23.31	22.05	16.11	9.41	14.08
						W_e = Experimental collection	100.0	12.39	20.85	24.47	16.63	9.18	16.48
						ratio W_o/W_e	1.216	1.118	0.901	0.969	1.025	0.853
						Calculated D_{po} of fraction collected	141.7	132.3	115.2	97.9	83.5	59.6

ciencies were calculated for the entire distribution of glass-bead sizes. Values of k for each chamber were found by trial which gave collection efficiencies such that the sum of the calculated weights of particles of each size group collected in each box agreed with the experimental collection.

The coefficients of performance of the separator chambers are plotted in Figure 6 against the separator width. Both the order of magnitude and the decrease with increasing separator-chamber width are considered reasonable.

By use of the experimentally determined values of k, Equation (14) was used to calculate the value of the particle-expansion ratio, r, from the experimental distribution of the spray dried product between the various boxes. As r may be a function of particle size for a given run, this procedure will give an arbitrary "average" value of r. The solution of Equation (14) for more than one unknown not being practical, this calculation procedure was necessary. The variation of r with particle size was obtained by correlation of the "average" values of r calculated from data of different runs. Values of r were calculated only for the runs with the smallest holdup of product in the dryer cone to reduce any possible error due to collection of an unrepresentative portion of the sample.

The calculation was made by assuming three trial values for r. A sample calculation for one trial value of r for run 15 is given in Table 1. The original size distribution was divided into fifteen convenient groups and the proportion of the total spray contained in each group was calculated from the integrated spray-droplet size-distribution function. For each trial value of r, collection efficiencies, η, were calculated from Equation (14) for each chamber for each group size. The total collection expected in a box was then obtained by a summation of the weights of each size group that these values of η predicted would be collected in that box. These calculated weights were compared with the experimentally determined values and the results plotted as shown in Figure 7. The best "average" value of r was taken as the one giving the best agreement between the calculated and experimental collection in the five gravity-settling chambers and the cyclones. Such "average" values of r were calculated for all runs having good collection efficiencies.

Since the drying-zone gas temperature was always between 420 and 450° F., and the standard deviation of the spray varied only from 0.155 to 0.177, there were only two operating variables which should affect the value of r. These are $\overline{D_{po}}$, which ranged from 65 to 120μ, and c, which ranged from 0.1 to 0.7 g. salt/g. water. No single correlation of all the experimentally determined particle-expansion ratios was possible by neglecting one of these factors. The best correlating function proved to be the mean product particle mass, $\overline{m_{pf}}$, defined by Equation (15):

$$\overline{m_{pf}} = \frac{\pi \overline{D_{po}}^3 \rho_o c}{6(1+c)} \qquad (15)$$

A plot of these average values of r against $\overline{m_{pf}}$ for these runs is given in Figure 8.

A different type of average r was obtained from the bulk density measurements, since by definition,

$$r^3 = \frac{c\rho_o(1-\epsilon)}{\rho_b(1+c)} \qquad (16)$$

The individual bulk density measurements for any given run showed no significant trend between the various collection boxes. This uniformity does not however imply that the apparent particle density does not vary with particle size, since the size distribution is greater in the first boxes, Table 1. Hence ϵ is lower in the first boxes than in the later ones because of filling in of void spaces between large particles by small ones. Thus the nearly uniform bulk density in all boxes for a given run indicated that the larger particles in the first few boxes have a lower apparent density than the small particles, thus counteracting the effect of greater size distribution to give a nearly uniform bulk density for all boxes. The difference in the average bulk densities for different runs must be attributed to differences in the operating variables.

As in the case of the calculated particle expansion ratios, the only variables which significantly differ between the various runs are c and $\overline{D_{po}}$. No continuous curve could be obtained by correlating the bulk densities with either of these variables alone, and again the mean product particle mass, $\overline{m_{pf}}$, was found to correlate all results in a reasonable manner. This correlation is shown in Figure 9. The lack of correlation of bulk density when neglecting particle size, and the reasonable correlation obtained by including its effect show that the larger particles formed during a given run are dried to less dense product particles than are the smaller particles formed during that run. In other words, the particle expansion ratio, r, is larger for large particles than for small ones, indicating a greater tendency on the part of large particles to form porous or hollow spheres during the spray-drying operation.

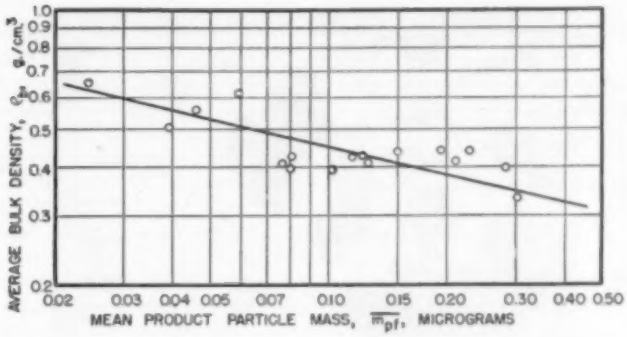

Fig. 9. Correlation of product bulk densities.

spray drying

Assuming a value of 20% for the fraction voids (which is a reasonable value for the ranges of particles sizes in each measurement), Equation (16) was used to calculate values of r from the bulk density correlation of Figure 9. These values are represented by the broken line on Figure 8.

The two lines on Figure 8 are not conflicting, the difference being due primarily to the fact that they represent two different types of average r. Neither line on Figure 8 should be considered to represent the true particle expansion ratio of a particle of a given mass. The quantity $\overline{m_{pf}}$ appears only as it correlates well with both types of *average* particle expansion ratios. Further insight into the meaning of the average particle expansion ratios may be obtained from the results of microscopic size measurements discussed below.

Representative samples of the powder collected in several boxes and in the dryer cone for run 30 were examined microscopically. The diameter of an adjusted total of approximately 1,000 particles was measured for each sample by use of an eyepiece scale calibrated against a standard micrometer. Volume-

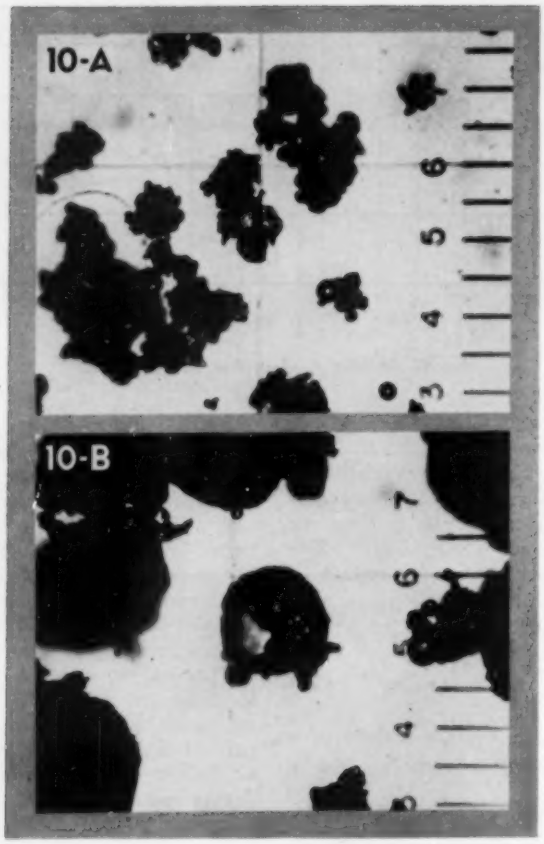

Fig. 10. Photomicrographs of collected product, run 30.
a) sample from box 4 (each scale space = 44.3μ).
b) sample from box 1 (each scale space = 44.3μ).

mean diameters * of these samples were computed from Equation (17).

$$\overline{D_{pf}} = \frac{\Sigma n D_{pf}^4}{\Sigma n D_{pf}^3} \qquad (17)$$

These microscopically measured mean diameters ranged from 221μ in Box 1 to 60μ in Box 6 and averaged 195μ for the entire collection.

Figure 10 shows photomicrographs of representative samples of particles collected in Boxes 1 and 4 on run 30, in which the size variation of particles in the two boxes is readily apparent. As can be readily observed, the particles are attached together, probably because of static electrical effects, and are not readily separated. Thus, some particles appear to be nonspherical on the photomicrographs, but they are in reality groups of spherical particles. The photomicrographs were taken at a single focusing position of the microscope lens system; during the size measurement, continuous changing of the focus made it possible to distinguish individual particles.

The microscopically determined final particle diameters were also compared to the original particle diameters for each box as calculated from Equation (14) for an assumed value of r of 1.25. The calculation of the original mass-mean diameter of the particles collected in a given box is fortuitously accurate even though the value of r is not accurately known. (The mean original particle diameters of the collection of the various boxes for run 15 were given in Table 1, along with the data from which they were calculated. These values change only 2% for a 25% change in r.)

The average value of r can vary widely depending on its definition. For example, r calculated from microscopically measured final diameters on run 30 was 1.53 for Box 1, 1.40 for Box 3, 1.09 for Box 5, and 1.87 for the entire collection. Comparison of the "average" value of r for run 30 of 1.52 calculated from Equation (14) with these microscopically determined values of r shows that Equation (14) gives an "average" value of r which is apparently the "true" value of r for the larger particles in Box 1.

The agreement between the microscopic size analysis and that predicted from the separator collection is considered to be good. This agreement also substantiates the applicability of Turner's equations to this system within the accuracy of his correlation of 8%.

Although the different types of "average" r used in this investigation complicate the discussion, all three methods of determining the particle expansion ratio of the spray-dried product agree with reasonable accuracy as to magnitude and relation to the fundamental operating variables. The tendency of large particles to form hollow or porous particles is substantiated by three different experimental methods of measurement—bulk density, particle settling rates, and microscopic measurement.

Since the particles of ammonium sulfate all apparently dried to their equilibrium moisture content of 0.038 wt. % even at the lowest attainable gas temperatures, no drying-rate equations can be proposed for this substance.

Some qualitative factors regarding the drying mechanism may, however, be deduced from the measured final particle diameters. It has been shown that many of the particles expand on drying, thus forming porous or hollow spheres. This tendency for expansion was further shown to increase with particle size as well as with feed concentration. Since the larger particles have a greater ratio of water-mass to surface area than do the smaller particles, expansion of the larger particles tends to equalize this ratio. The slope of a curve on Figure 8 which would correspond to keeping the ratio of surface area to water-mass (or solvent evaporation) constant, falls between that of the two lines shown. Thus, the order of magnitude of particle expansion is such as to keep the surface area to water-mass ratio nearly uniform for all particles. Therefore, the surface rate of evaporation per unit area is the same order of magnitude for all sizes of particle on a given run.

Whether this factor is significant to the drying mechanism cannot be determined, but at least it is certain that a complete elucidation of the drying mechanism of ammonium sulfate (and other similar substances) must allow for the increased expansion with increasing particle size.

Comparison with Results of Others

Inasmuch as no previous studies have been reported on the extent of gas mixing in a drying chamber, no com-

* Since the larger particles formed during a given run have a lower apparent density than do the smaller particles, the mass-mean diameter and volume-mean diameters are different. This fact complicates the interpretation of the microscopic measurements, since only the volume-mean diameter can be determined.

parison of the results of that phase of this investigation may be made. The results of the factors affecting product size and bulk density may, however, be compared to those of several other investigations.

Waldorf (15) made a brief study of the spray-drying of sulfite waste liquor (calcium lignosulfonate solutions) with the same experimental equipment as that used in this investigation. This substance also showed a greater tendency for hollow-sphere formation by the larger particles on a given run, thus demonstrating that the same qualitative drying mechanism may apply to compounds differing widely in fundamental properties.

Several investigators have determined the effect of feed concentration (holding all other factors constant) on the bulk density of many substances. These are summarized by Duffie (*3*). For those investigations using inorganic salts, increase of feed concentration results in a decrease of product bulk density, in agreement with the results of this investigation.

Duffie (*3*) dried large (250-650μ original diameter) droplets of several inorganic salts and found in nearly every case that the product particles were hollow spheres of larger diameter than the droplets from which they were formed. No quantitative correlation of the factors affecting product particle size was reported, but the results are at least in qualitative agreement with the results of this investigation.

Ranz and Marshall (*12*) studied the drying of single drops of inorganic salt solutions of initial diameters about ten times those used in this investigation. Their results indicated no increase in diameter during the falling-rate period of drying. However, since their drying times were about 1,000 times as long as those for the particles in this investigation, a different mechanism would be expected from that for the rapid drying occurring in this investigation. Thus, the results of the two investigations cannot be directly compared.

Conclusions

The spray drying operation can be studied from a fundamental standpoint by combining the many operating variables into c, $\overline{D_{po}}$, $\overline{\sigma}$, and t. The effect of the first two on product properties was studied in this investigation.

For the experimental equipment and range of operating variables used in this investigation, vertical gas mixing occurs in the drying chamber to the extent of about three quarters of perfect mixing. The vertical gas mixing results in a relatively constant gas temperature in the drying zone, and greatly increases the spread of residence times of small particles in the drying chamber over that which otherwise would be expected.

The bulk density of the spray-dried ammonium sulfate decreases with an increase of both feed concentration and particle size, the best correlation being with their combination in the form of mean product particle mass.

The particle expansion ratio, r, of spray-dried ammonium sulfate increases with both particle size and feed concentration. The average particle expansion ratio for a given run increases linearly with the mean product particle mass. The order of magnitude of particle expansion is such as to keep the surface area to mass ratio nearly uniform for all particles.

Notation

A_s = height of gravity settling chamber
B_s = width of gravity settling chamber
c = feed concentration, g. solid/g. water
C_s = length of gravity settling chamber
D_p = particle diameter
subscripts: o original, as found in spray
f final
D_a = diameter of the air core in the nozzle orifice
D_n = nozzle orifice diameter
g_c = gravitational conversion factor
h = coefficient of heat transfer from particle surface
k = coefficient of performance of settling chamber
k_f = thermal conductivity of gas film
l = length of particle path in dryer
m_p = mass of particle
$\overline{m_{pf}}$ = mass of product particle with average original diameter
n = number of particles of a given measured size
r = expansion ratio of particles, D_{pf}/D_{po}
t = gas temperature
t_n = gas temperature at nozzle location
T = liquid or solid particle temperature
T_s = feed solution temperature at nozzle
v = relative velocity between particle and air
v_o = initial relative vertical velocity between particle and air
v_t = terminal relative velocity between particle and air
v_g = average velocity of gas without recirculation
w = liquid feed mass flow rate
W = mass flow rate of gas

GREEK LETTERS

γ_s = surface tension of feed solution, dynes/cm.
ϵ = fraction voids in packed bed of particles
η = settling chamber collection efficiency (probability of collection of a particle in a chamber)
θ = time in drying zone
λ = latent heat of vaporization of solvent
μ_g = viscosity of gas (calculated for mixtures by assuming fluidity to be a molar additive property)
μ_s = viscosity of feed solution
π = ratio of circumference to diameter of circle, 3.1416
ρ_b = bulk density of product
ρ_g = density of gas
ρ_s = density of feed solution or sprayed particles
$\overline{\sigma}$ = mean standard deviation of spray for adjusted logarithmic probability distribution function
Σ = mathematical operator indicating summation
ϕ = angle between spray cone and vertical

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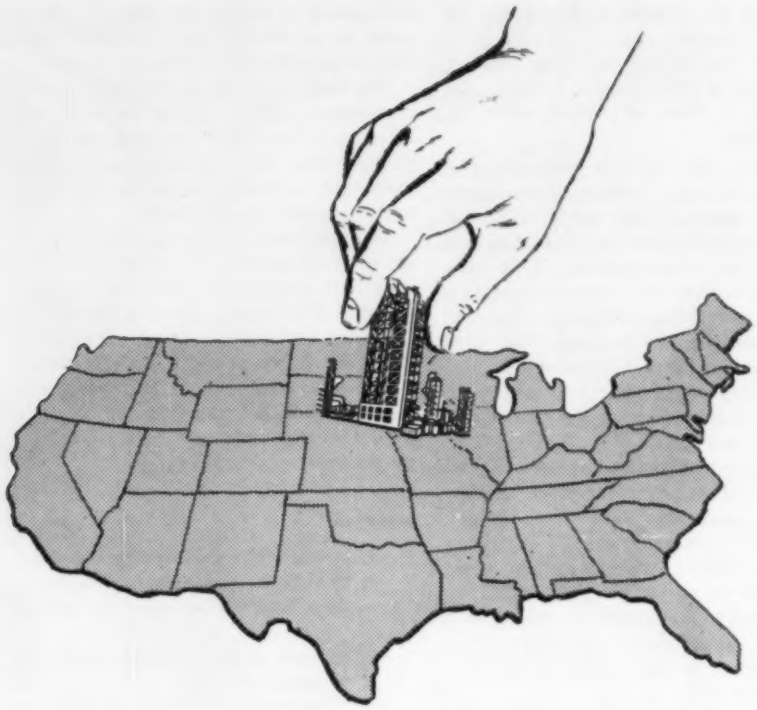

the selection of a plant site

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The selection of a plant site is a top-drawer decision having a strong influence upon the economics of product competition. Proper selection can result in a competitive advantage; poor selection in an economic burden. The factors influencing the final decision on plant location are so many and so varied that it is only after continual refiltering of particular location qualifications that a healthy decision can be reached.

The pattern of historical development, if properly scrutinized, does reveal a system by which the most profitable decision can be made. The influencing factors accumulated through experience can be applied as a methodical step-operation to disqualify areas lacking one or many of the requisites attached to any particular product manufacture. The procedure discussed here will reduce to a minimum the choice of sites, which then can be considered more from a speculative than from the requisite standpoint for optimum economic operation.

When an investment in new manufacturing facilities is projected, the site chosen as a location for the new plant affects both the amount of capital invested and the production and distribution costs. For example, if the new plant is not close to its source of raw materials and to its customers, transportation costs will be higher. Larger inventories which may accompany a location remote from raw materials sources and from markets will require more working capital and more investment in storage facilities. If the location is where the labor supply is inadequate, there is a risk of excessive labor costs for construction and for production. Whatever are the effects of poor selection, they will be carried forever as an economic burden.

Though every business venture incurs a risk in using capital funds for constructing new manufacturing installations, still there are no infallible guides in selecting a location that will insure profitable operation until the plant is

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obsolete or worn out. But the factors which affect the economics of all manufacturing operations are generally known and should be carefully considered in relation to a possible location. In the process it must be recognized that conditions are certain to change in some fashion after the plant is built. Possession of flexibility to meet changing conditons is a prime requisite for launching a new enterprise. Providing the venture with flexibility through the wise selection of a site means locating where the economics of the operation is influenced least by factors beyond the control of the owner.

In the selection of a plant site each situation must be dealt with as an individual case. Each of the influencing factors must be weighed against the particular demands of the new plant and evaluated according to relative importance. The particular circumstances involved will determine whether a given factor is controlling, or is of minor significance. As an example, in Southeastern United States, the favorable climate and the proximity to markets make attractive locations for textile plants. Water transportation and an abundance of raw material favor the selection of plant site locations for the petroleum industry in the South Central portion of the United States.

This discussion is limited to the selection of a site for a process industry plant. In this instance the process industries are defined as the chemical industry, petroleum industry, textile industry, and pulp and paper industry. It is assumed that the new plant is not to be located adjacent to existing facilities operated by the same owner.

Factors Influencing the Selection

Factors which apply in general to the selection of a plant site for a process industry may be classified as follows.

(1) Raw Materials Supply
(2) Market Location
(3) Power and Fuel Supply
(4) Climate
(5) Water Supply
(6) Waste Disposal
(7) Transportation Facilities
(8) Taxes
(9) Regulatory Laws and Practices
(10) Labor (availability and rates)
(11) Proximity to Other Industries
(12) General Surroundings
(13) Site Characteristics
(14) Living Conditions

Of the factors discussed here, the first four, raw material supply, market location, power and fuel supply, and climate are termed primary factors and are related chiefly to regional features. The remaining ten, although not necessarily of lesser importance, apply to specific sites rather than to regions or large areas and are termed secondary factors.

Raw Materials

Raw materials probably exert a stronger influence in the selection of a plant site than any other single factor. This influence is dependent upon the nature and the volume of the materials. Having the source of raw material close to the plant is especially important when the volume is large because distance from raw materials source requires storage for a continuous supply and probably expensive transportation. The relationship of market location to plant location is of importance in influencing not only the costs of distribution but also the time required for shipments of the product to reach the customer, who also finds advantages in having his raw materials close at hand.

Power and Fuel

Power and fuel as factors in the selection of a plant site are closely related because, with the exception of hydroelectric power, the generation of power requires the use of fuel. Fuel is usually required in addition to power because of the requirement for steam which is so general in plants of the process industries. The generation of steam for process purposes provides an opportunity to generate power as a by-product. It may be preferable, however, to purchase power in order to save on initial investment.

Climate

Climatic conditions such as excessive humidity, torrid heat, or excessive cold will affect the economics of operation. The investment required for construction of a plant in a northern climate will exceed that in a southern climate because of the greater necessity for enclosing the facilities and for providing protection against freezing. Air conditioning may be necessary in extreme southern locations. Climate is especially important in the textile industry, in which many of the operations must be rigidly controlled for temperature and humidity.

Water Supply

Because plants in the process industries generally use water in large quantities, not only for process cooling but also for steam generation, and even as a raw material, the site must be located near water. Process industries plants utilize lakes, oceans, and even wells as sources of water, but a river of substantial size is generally preferred. If the flow of water is irregular, it may be necessary to construct a reservoir. The temperature, bacteriological content, and mineral content must be considered in the choice of water supply; treatment of water to remove or correct undesirable characteristics adds to production and investment costs.

Transportation

The usual means of transportation utilized by the process industries are water, rail, and highway. Water transportation, although cheaper per ton-mile than the other means, may involve higher fixed investment and greater working capital. Water transportation is often slow and irregular and is characterized by infrequent service. Advantages of prompt service may influence the transportation method for the finished product and, to a lesser extent, for raw materials and fuel. Transportation by motor trucks is a practical means for shipping small quantities over short distances, but for the most part the process industries depend heavily on rail transportation. One factor in regard to transportation must not be overlooked; that is, the plant should be located where it is reasonably accessible by railroad and air to the headquarters of the company's business and technical branches.

plant location

Waste Disposal

The disposal of wastes from a plant in the process industries may be a factor of great importance. Because of legal restrictions, such disposal is becoming increasingly more difficult. A plant site should be selected where process wastes can be disposed of properly, and the costs of this must be regarded as a necessary part of the operation. It cannot be assumed that any given site will continue to remain free of restrictions against pollution. Even if the wastes are not considered to be objectionable and even if there are no local restrictions at the time the site is selected, new plants should be planned so that an effective method of waste disposal is available for future use.

Labor

Although labor cost is seldom a controlling influence in the determination of a plant's location, it is necessary to examine the vicinity of any proposed site in order to ascertain the availability of the labor required, both for construction and operation. If the supply of labor in the area is inadequate, high costs and instability in industrial relations may be the result.

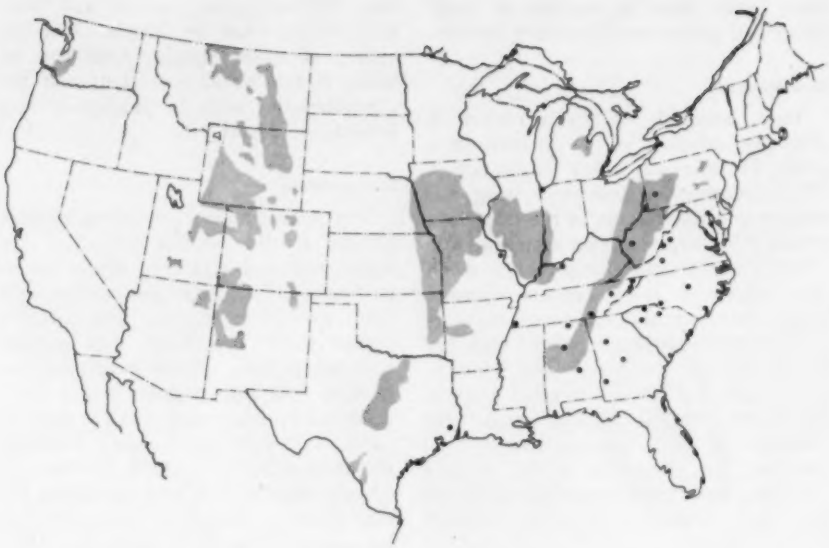

Fig. 1. Location of markets and coal fields in the United States.

Taxes

Federal taxation has no bearing on plant location because federal taxes are the same everywhere, but local taxation must be taken into account in the selection of a plant site. State and local taxes include income tax, unemployment insurance tax, franchise tax, use tax, and property taxes. The rates for these taxes vary widely and the tax situation must be considered separately and individually for each proposed site. In some localities, special concessions in the form of low tax assessments or limited-term tax exemptions on machinery and real estate are made to attract new construction.

Regulations

In examining the merits of a proposed site, the possible effects of local regulations and practices must not be overlooked. Among those which must be considered are building codes, laws on disposal of wastes and fumes, zoning ordinances, and highway restrictions. Location of a new plant in an area where there are other plants, particularly those having similar operations, has both advantages and disadvantages. In such situations it may be possible to obtain better railroad rates and better utility services as well as a supply of labor with the proper skills, but the establishment of favorable industrial relations policies for the new plant may be hampered by entrenched practices.

Rural Locations

A tendency noted in recent years has been for the process industries to locate new plants in rural areas. Rural locations make it easier to avoid undesirable neighbors. They also have the advantages of cheap and plentiful land, few restrictive ordinances, and low taxes. Land values are generally higher around cities, which makes it more economical to obtain room for future expansion by the selection of a rural location. Proximity to centers of population, however, may have advantages in the matter of labor supply.

Site Characteristics

The characteristics of the proposed site, as a tract of land, must be carefully reviewed before final selection is made. The site should have ample room for expansion; the cost of land is a small proportion of the total cost of the average process industry plant. The site must have ready access to highway and railroad as well as to water supply. The contour of the site and the soil structure must both be evaluated because they have an effect on the costs of construction. Earth moving is a costly construction operation and a level site is highly desirable.

Living Conditions

The living conditions in the plant neighborhood is an important item in industrial relations. The community surrounding the plant site selected must contain adequate housing, schools, churches, recreational facilities, and shopping facilities.

Procedure—Steps in Making the Selection

The six steps involved in applying the factors previously described to the selection of a plant site comprise, in general, weighing the requirements of the new plant against the characteristics of various site possibilities. The economic basis for this evaluation is found in the estimates of raw materials, utilities, labor, and sales outlets prepared for the new plant.

Although the factors governing plant location should be reduced to economic terms insofar as possible, in considering the selection of a new plant site, factors other than economic usually receive attention. Business policy relating to such matters as competition, distribution, finances, trade trends, and pricing may exert a strong influence.

The *first step* in the procedure for selecting a plant site is to consider the influence of the four primary factors that usually determine in which region the proper site is most likely to be located. For the purpose of providing a background for illustration, one can assume a hypothetical operation using coal as raw material and producing a rather bulky product sold to other manufacturers for further processing. A map of the United States is first prepared to show the location of the principal coal fields. On this map is also indicated, by solid circles, the location of the various customers for the plant's product (Figure 1).

On this map it may be seen that the Southeastern region of the United States will not only supply the raw material needed but it also contains most of the customers. This region, having coal in abundance, can be assumed to offer no disadvantages in fuel and power supply. Climate in this region offers no problems. Other regions may then be eliminated from further consideration, which is the *second step*.

Attention is now directed on the Southeastern region to determine where the circumstances are favorable for satisfying the requirements of the secondary factors, the *third step*. Of paramount importance is water supply. Our hypothetical plant needs plenty of water for its cooling and condensing equipment and a large stream would be helpful in disposing of treated process wastes. Hence, a map of the southeastern states is drawn with the major rivers sketched in (Figure 2).

An important factor which enters at this point is transportation facilities. Our customers are well scattered. The rivers of the southeastern states are not well-arranged for river transportation. Railroad transportation seems indicated. The preceding map of the southeastern states is now amended to draw in the railroad lines (Figure 3). This hypothetical plant cannot be located very far from either a river or a railroad line. At each river-railroad intersection a block

Fig. 2. Location of rivers, coal fields, and markets in the Southeastern United States.

Fig. 3. Railroad-river intersections in the Southeastern United States.

is drawn in representing an area of about 10 square miles. In the whole of the southeastern states shown on this map the total area is about 461,000 square miles. Assuming that it is not practical to locate the plant more than one mile from a major river, the possible area is limited to about 14,000 square miles. With an allowance of 10 square miles for each of the river-railroad intersections, the possible area is reduced further to about 1500 square miles. By this procedure, the area is reduced from 461,000 square miles to 1500 square miles. On this basis the usable area is only about one third of one per cent of the total possible area.

Even the area thus limited offers too many locations for practical detailed examination. A rough study should now be made of the incoming and outgoing freight to establish the traffic density pattern. Railroad freight rates in the United States are quite confusing and a competent traffic manager should be consulted in the evaluation of rail transportation costs. A preliminary study of the tax laws and the regulatory laws and practices of each of the states in the region should also be made. With these additional data to use in further reducing the possibilities, it is feasible to choose a "target area" where the most favorable sites in the region are located (Figure 4).

At this point in the procedure, the job has progressed to a stage where outside aid can be solicited, the *fourth step*.

plant location

Fig. 4. Plant site "target area."

Railroads and utility companies, and even public organizations, for obvious reasons, maintain an inventory of all attractive industrial sites within the territory they serve. By communicating with those whose territory is within the "target area," information can be secured on available sites and on the qualities of these sites.

As the *fifth step*, each of the sites offered can be appraised, either from the information supplied by the promoter or from that obtained by brief inspection, to select the better ones for further, closer examination. In this appraisal, attention is directed to the general surroundings, proximity to other industries, and site characteristics. The availability of labor and the labor rates must be carefully scrutinized also. Much useful information on labor availability and rates can be obtained from the Department of Labor of the various states under consideration. For appraising the labor situation, the services of industrial relations experts are indispensable.

As the *sixth and final step*, each of the sites surviving step five are examined critically, and the influence of each of the ten secondary factors is reviewed. The tax studies and the transportation studies which were performed in a preliminary fashion in choosing a "target area," the third step, must now be repeated more intensively. Particular attention must be given to site characteristics and living conditions. This, of course, can be accomplished only by careful on-the-spot inspection. In this final inspection, weight must be given to the probable future course of the business for which the plant site is being selected.

Presented at ninth annual one-day South Texas Section meeting.

relative volatility of binary mixtures from a fractionating column at finite reflux

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The essence of vapor-liquid-equilibrium determination is to establish the curve $y = f(x)$ of Figure 1. A point x_i, y_i on this curve may be found by taking advantage of the fact that under pinch conditions the point x_s, y_s is at the intersection of the equilibrium curve and the operating line. The equation for the operating line written in its usual form, but in terms of R rather than in terms of liquid and vapor flow rates, is

$$y_n = \frac{R}{R+1} x_{n+1} + \frac{x_D}{R+1} \qquad (1)$$

For pinch conditions with $x_s = x_{s+1}$, this becomes

$$y_s = \frac{R}{R+1} x_s + \frac{x_D}{R+1} \qquad (2)$$

Thus if x_D, x_s, and R are measured experimentally under pinch conditions, a value for y_s may be calculated. Other experimental measurements under pinch conditions with different values of x_D, x_s, and R will yield other values of y_s, each giving the vapor-liquid-equilibrium compositions for the corresponding value of x_s. Values of relative volatility may be calculated from any or all of these pairs of x_s, y_s values by use of the equation

$$\alpha = \frac{y_s/1-y_s}{x_s/1-x_s} \qquad (3)$$

If desired, the last two equations may be combined to give

$$\alpha = \frac{R(1-x_s) - x_D + \frac{x_D}{x_s}}{R(1-x_s) - x_D + 1} = \frac{R + \frac{x_D}{x_s}}{R + \frac{1-x_D}{1-x_s}} \qquad (4)$$

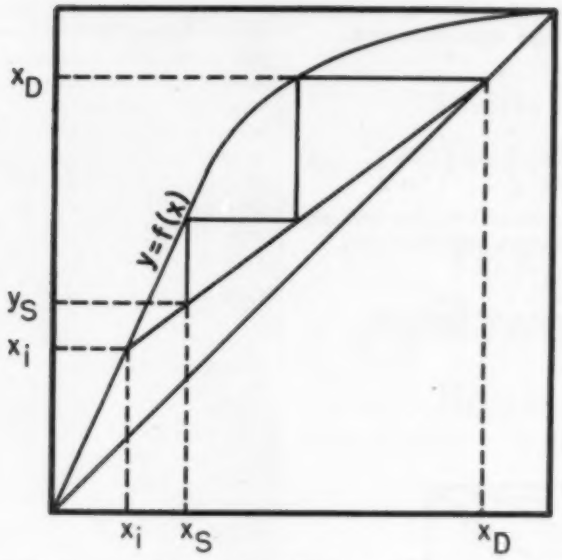

Fig. 1. Representation of pinch conditions in a fractionating column and the basis for derivation of equations for calculating relative volatility from end compositions.

If Equation (4) is applied to a simple distillation where $R = 0$, it reduces to

$$\alpha = \left(\frac{y}{1-y}\right)\left(\frac{1-x}{x}\right) \qquad (5)$$

which is used to calculate relative volatility from composition data obtained in a one-plate equilibrium still.

Examples of Use of Equations—Synthetic Data

The use of Equation (4) may be illustrated by taking synthetic x_D and x_B values from tabulations and curves previously obtained for another purpose in this laboratory (*4*). These values were obtained by plate-to-plate calculations for various values of n and R for systems with relative volatilities of 2 and 1.074. Application of Equation (4) to these x_B, x_D values should give the values of α used in the plate-to-plate calculations. The values in Table 1 show that the relative volatility can be calculated by Equation (4) within the accuracy of x_D and x_B.

Experimental Procedure

In the practical application of this method, it is necessary to make certain that pinch conditions exist. This may be done by making a series of experimental determinations at different reflux ratios but with the same x_B. If the resulting x_D, x_B data obtained at these different reflux ratios give a series of nearly identical values of α, it is proof that pinch conditions existed in all the determinations, that Equation (4) is applicable, and that the series of nearly identical values are close to the true value of the relative volatility. When the values of α calculated from Equation (4) vary as the reflux ratio varies, it is necessary to carry out further experiments with lower reflux ratios or more theoretical plates until proof of pinch conditions is obtained.

Experimental Verification

The column used to test the validity of Equation (4) was originally designed as a batch purification column. It had an inside diameter of 2 in. and was packed with 20 ft. of 0.16- by 0.16-in. protruded packing. Adiabaticity was maintained by means of a heated jacket kept near the distillation temperature. The column was operated as a steady state enriching section by returning part of the reflux stream from the condenser directly to the still pot so as to achieve finite reflux conditions. The rate at which the product was returned to the still pot was set with a needle valve, and the boil-up rate was controlled by maintaining enough heat input to give a constant pressure drop of 30 mm. Hg through the column. Top and bottom rates were determined by measuring the time required to fill a cylinder of known volume. A correction for the heat lost in the fittings at the bottom of the column was made by noting the bottom rate when the throughput was reduced until vapor no longer reached the condenser and subtracting this rate from each bottom rate measured in subsequent runs. The pressure in the still pot averaged 766 mm. Hg during these runs.

The test system used was *n*-heptane–methylcyclohexane. Each component had been purified by distillation through a column with over one hundred plates at a high reflux ratio. Analysis was made by refractive index using a Valentine refractometer graduated to 0.0001 unit of refractive index. Rossini and coworkers have reported that this system is ideal (*6*).

A series of eleven sets of x_D, x_B readings were taken over a period of 2 days.

Table 1.—Illustration of Use of Equation (4)

As used in plate calculation	x_D	x_B	R	From Eq. (4)
2	0.9082	0.0986	9	2.001
2	.8582	.0921	9	2.001
2	.7982	.0845	9	2.001
2	.7482	.0783	9	2.001
2	.6882	.0711	9	2.001
2	.6282	.0641	9	2.001
2	.5582	.0561	9	2.001
2	.4482	.0441	9	2.001
2	.3582	.0346	9	2.002
2	.2482	.0235	9	2.002
2	.1282	.0119	9	2.001
2	.0582	.0053	9	2.009
1.074	.9500	.8564	10	1.0736
1.074	.9000	.7599	10	1.0737
1.074	.8000	.6164	10	1.0738
1.074	.7000	.5044	10	1.0738
1.074	.6000	.4095	10	1.0738
1.074	.5000	.3259	10	1.0738
1.074	.4000	.2505	10	1.0737
1.074	.3000	.1813	10	1.0737
1.074	.2000	.1171	10	1.0735
1.074	.1000	.0570	10	1.0730

Experimental Results

The relative volatilities calculated by Equation (4) by use of the data obtained with the apparatus and procedure just described are given in Table 2. These values agree well with the value of 1.075 calculated from vapor pressure data (*6*).

Table 2.—Experimental Values of the Relative Volatility of *n*-Heptane - Methylcyclohexane Obtained by Equation (4)

R	x_D	x_B	
15.8	.6522	.3799	1.071
11.3	.5973	.3857	1.075
12.3	.6105	.3837	1.074
14.8	.6423	.3802	1.072
9.4	.5648	.3842	1.076
9.2	.5627	.3854	1.076
10.1	.5696	.3848	1.072
10.6	.5799	.3828	1.074
10.7	.5882	.3814	1.077
12.4	.5953	.3796	1.070
13.4	.6237	.3753	1.076
14.7	.6351	.3744	1.073
			Avg. 1.074

Application to Nonideal Systems

Figure 1 shows a McCabe-Thiele diagram for a nonideal system. As the number of theoretical plates is increased above the two shown, x_g approaches x_i regardless of the shape of the equilibrium curve over the range x_g, x_D, because the shape of the curve between x_g and x_D affects only the number of plates required to reach the pinch, not the value of x at the pinch. With pinch conditions, that is, with more than enough plates to reach the pinch, and at constant reflux ratio and x_D, the value of x_g depends only on relative volatility at this composition. The value of α calculated from Equation (4) is therefore the relative volatility at x_g. The variation of α with composition can be determined by operating at various values of x_D and x_g.

This may be more clearly demonstrated by consideration of the determination of α for $x_g = x_i$ for each of the two mixtures whose $x - y$ curves are given in Figure 2. If each of the determinations was made with the top composition x_D and if in each case the column had enough plates to achieve pinch conditions, then the value of α that was obtained would correspond to y_g.

Application to Instantaneous Compositions from Batch Distillations

Since Figures 1 and 2 can represent conditions at one instant in a batch distillation with negligible holdup, Equation (4) can be applied directly to simultaneous values of x_D and x_g obtained during batch distillation provided that pinch conditions exist so that x_g equals x_i at that point.

Equation (4) can also be combined with the Rayleigh equation to give

$$\ln \frac{S_1}{S_2} = \frac{1}{(R+1)(\alpha-1)} \left[\alpha \ln \left(\frac{1-x_{g_2}}{1-x_{g_1}} \right) + \ln \left(\frac{x_{g_1}}{x_{g_2}} \right) \right] \quad (6)$$

Solving for relative volatility and converting to common logarithms gives

$$\alpha = \frac{\log \left[\left(\frac{S_1}{S_2} \right)^{R+1} \left(\frac{x_{g_1}}{x_{g_2}} \right) \right]}{\log \left[\left(\frac{S_1}{S_2} \right)^{R+1} \left(\frac{1-x_{g_1}}{1-x_{g_2}} \right) \right]} \quad (7)$$

A mean value of α is obtained where there is variation in relative volatility.

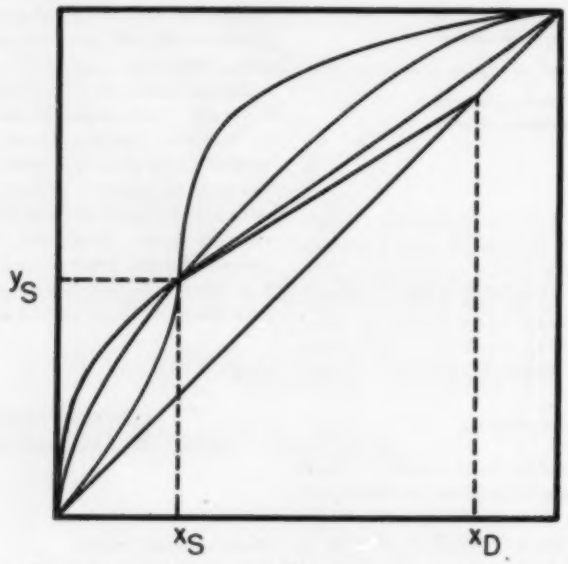

Fig. 2. Representation of relations for several nonideal mixtures with one common point.

Approximate Values of α from Nonpinch x_D, x_g Data

If x_g does not differ greatly from x_i, the calculated relative volatility does not differ much from the true value. This may be demonstrated as follows.

In the course of an investigation on the effects of holdup in batch distillation, Kahn (1) made a batch distillation of methylcyclohexane and *n*-heptane at a reflux ratio of 20 in a column containing fifty-five theoretical plates at this reflux ratio. Holdup was 3% of the charge, and the still pot composition varied from 67.19 to 8.8 mole % of *n*-heptane. The average value of relative volatility for this distillation calculated from Equation (4) was 1.0715, and from Equation (9) it was 1.0711. Both these values are comparatively close to the values given by various authorities for this system.

Peters (3) used return to still operation to study the effect of reflux ratio on column efficiency under vacuum. Using *n*-decane–*trans*-decalin as a test mixture and a constant packed height, he varied the reflux ratio from 33.7 to 2.88. A plot of α calculated from Equation (4) vs. R showed that as the reflux ratio was decreased and the distillation approached conditions at the pinch, α appeared to approach a value of 1.18 at 50 mm. and of 1.106 at 10 mm. Meyers (2) found the relative volatility of this mixture to be 1.19 at 50 mm., and the data of Struck and Kinney (5) gave a value of 1.21 at 50 mm. and of 1.107 at 10 mm. It is possible therefore to obtain reasonable approximations of α from data in which no special attempt was made to secure pinch conditions.

The method is applicable to multicomponent mixtures.

Acknowledgment

The authors are indebted to William W. Sanders for his advice during the course of this work and for his help in deriving Equation (6).

Notation

- α = relative volatility as defined by Equation (5)
- n = number of theoretical plates in column
- R = reflux ratio expressed as moles of distillate returned to column per mole removed as product or returned directly to still
- S = moles of charge in still pot at any time
- x = mole fraction of more volatile component in liquid
- x_D = mole fraction of more volatile component in distillate
- x_i = mole fraction of more volatile component in liquid at pinch-point composition
- x_g = mole fraction of more volatile component in still pot
- y = mole fraction of more volatile component in vapor
- y_i = mole fraction of more volatile component in vapor which is in equilibrium with liquid of pinch-point composition
- y_g = mole fraction of more volatile component in vapor which is in equilibrium with liquid in still pot

Subscripts 1 and 2 refer to two points in a batch-distillation curve.

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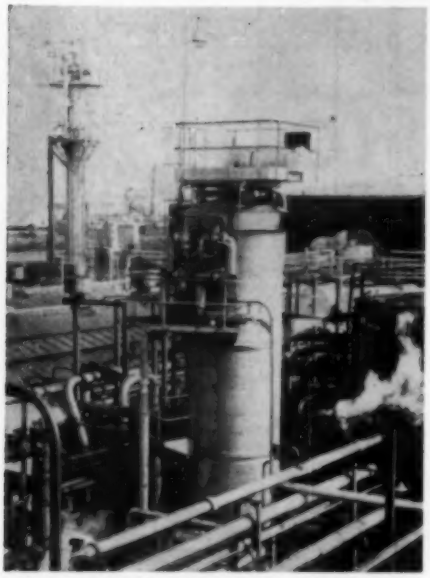

Fig. 14. Rotating-disc contactor in 2,000 bbl./day furfural extraction unit at Shell Haven Refinery, England.

THE ROTATING-DISC CONTACTOR—a new tool for liquid-liquid extraction

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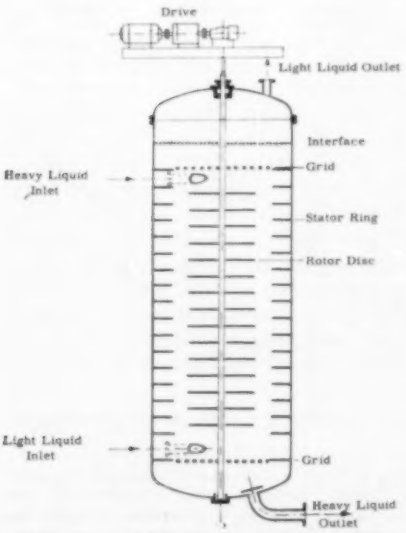
R. B. Olney — Shell Development Company, Emeryville, California

Out of an intensive research over the past several years by the Shell Companies, a new type of countercurrent extraction apparatus–the rotating-disc contactor–has evolved.

This apparatus has been thoroughly tested in large-scale commercial solvent extraction applications and has been proved to be highly efficient, simple, and cheap to operate, and easy to maintain. It has a high volumetric efficiency, is of straightforward construction, and for equivalent capacities is cheaper to build than other existing apparatus of comparable efficiency. An outstanding advantage is that there is no or hardly any loss in efficiency on scaling up to high commercial capacities. Moreover, since an individual rotating-disc contactor will retain its efficiency over a wide capacity range, flexibility of operation is assured.



Rotator disc contactor; interface in top compartment.

Apparatus

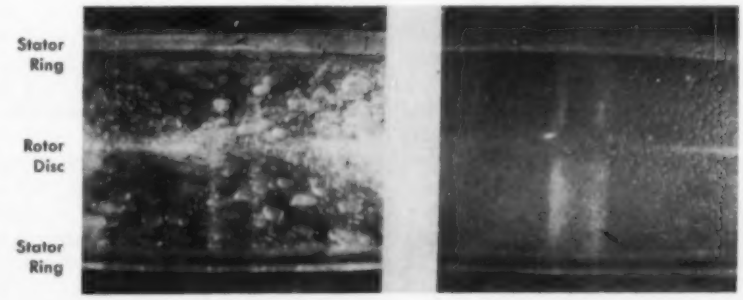
The contactor (see Figure 1) consists of a number of compartments formed by a series of stator rings, with a rotating disc centered in each compartment and supported by a rotating shaft. In the larger diameter units (diam. more than 2 ft.) the feed inlets are preferably arranged tangentially in the direction of rotation. An extra stator ring and a wide mesh grid are fitted into the shell to separate the feed inlet zone from the settling compartment. This design has proved to be effective in minimizing disturbance in the settling compartments. The method of construction permits the use of corrosion-resistant materials.

In most applications the contactor operates at substantially atmospheric pressure, but in some cases it is designed to operate at moderate positive pressures (up to 70 lb./sq.in. gauge). Development work on high-pressure applications is in progress.

MODE OF OPERATION

The lighter liquid enters the contactor at the bottom and flows upwards countercurrently to the descending heavier liquid, which enters at the top. One of the liquids will be dispersed and the size of the droplets formed is controlled in each compartment by rotor speed. Variation in the rotor speed provides a simple and effective method of obtaining optimum extraction conditions in each case. This feature of the contactor is illustrated in the adjoining photographs (Figure 2) of a plastic model of one compartment.

The principle of contacting the liquid phases as embodied in the rotating-disc contactor stands in sharp contrast to that applied in most conventional types of commercial apparatus. In the latter apparatus an attempt is made to secure a large interfacial area and rapid initial transfer by repeating a number of times the process of dispersion under highly turbulent conditions followed by coalescence. However, the uniformity



Rotor speed 100 rev./min. Rotor speed 200 rev./min.

Fig. 2. Control of droplet size by variation in rotor speed.

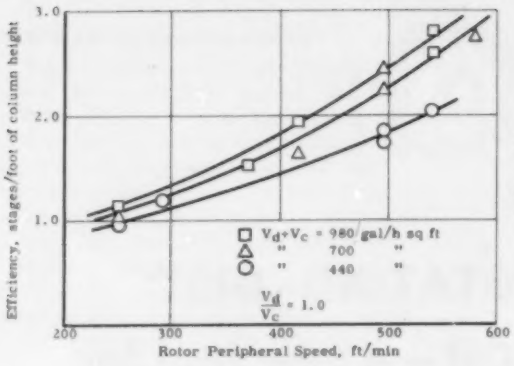


Fig. 3. Effect of rotor speed on efficiency for various loads.

System MIBK — water — acetic acid; water dispersed; 8-in. rotating-disc contactor; rotor diam. 3.1 in., stator opening 4.9 in., compartment height 1.6 in., 21 compartments.

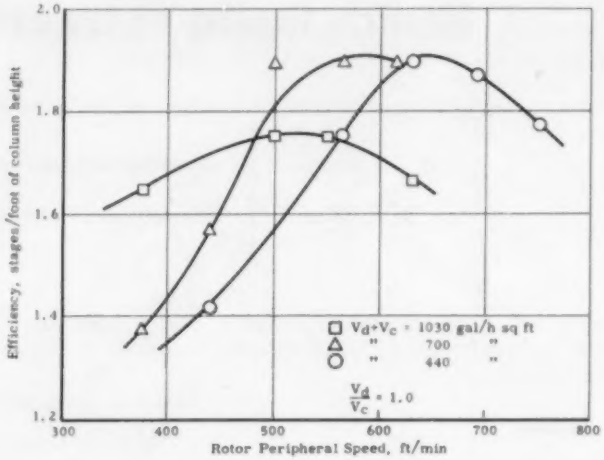


Fig. 4. Effect of rotor speed and specific load on efficiency; back mixing is effective.

System MIBK—water —acetic acid; water dispersed; 8-in. rotating-disc contactor; rotor diam. 4.7 in., stator opening 6.3 in.; compartment height 2.4 in., 14 compartments.

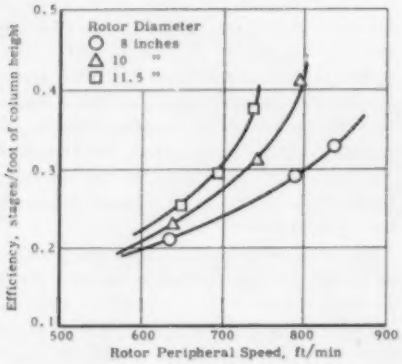


Fig. 5. Effect of rotor size on efficiency.

System kerosene — water — n-butylamine; kerosene dispersed; 16-in. rotating disc contactor; stator opening 12 in.; compartment height 4 in., 12 compartments; water rate 3.8 gal./min.; kerosene rate 12.0 gal./min.

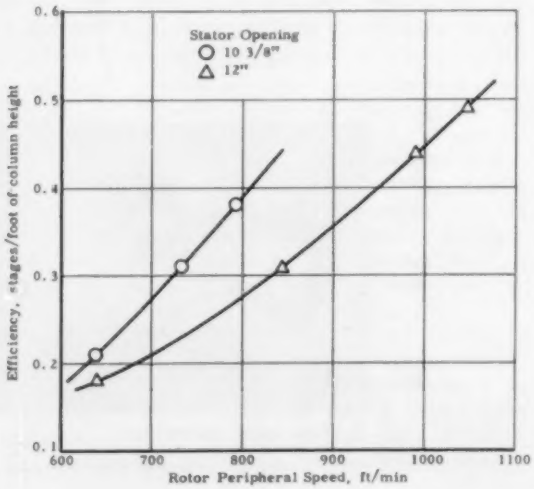


Fig. 6. Effect of stator size on efficiency.

System kerosene — water — n-butylamine; water dispersed; 16-in. rotating disc contactor; rotor diam., 10 in.; compartment height 4 in., 12 compartments; water rate 3, 8 gal./min., kerosene rate 12.0 gal./min.

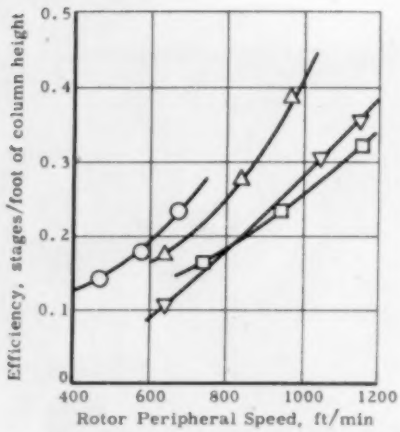


Fig. 7. Effect of compartment spacing on efficiency, water phase dispersed. System kerosene—water—n-butylamine; water dispersed; 16-in. rotating-disc contactor; rotor diam. 8 in., stator opening 12 in.; water rate 7.66 gal./min., kerosene rate 12 gal./min.

water dispersed	compartment spacing, in.	contact zone, in.
○	2.4	48
△	4	48
□	6	48
▽	8	48

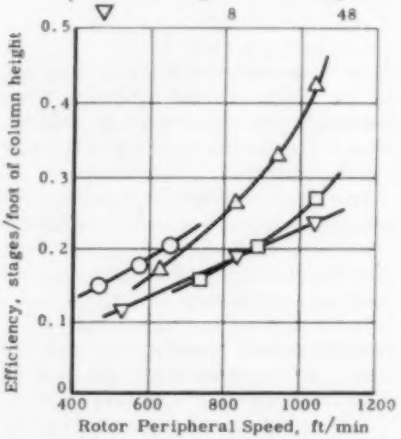


Fig. 8. Effect of compartment spacing on efficiency; hydrocarbon phase dispersed.

System kerosene—water—n-butylamine; kerosene dispersed; 16-in. rotating-disc contactor; rotor diam. 8 in., stator opening 12 in.; water rate 7.66 gal./min., kerosene rate 12 gal./min.

kerosene dispersed	compartment spacing, in.	contact zone, in.
○	2.4	48
△	4	48
□	6	48
▽	8	48

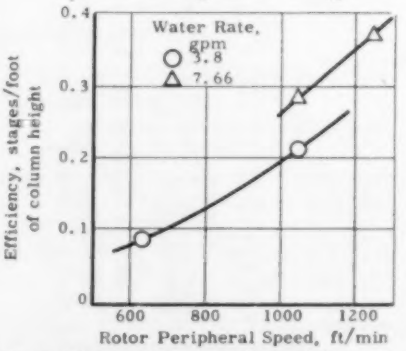


Fig. 9. Effect on efficiency of dispersed flow rate.

System kerosene—water—n-butylamine; water dispersed; 16-in. rotating-disc contactor; rotor diam. 8 in.; stator opening 12 in.; compartment height 8 in., 6 compartments; kerosene rate 12.0 gal./min.

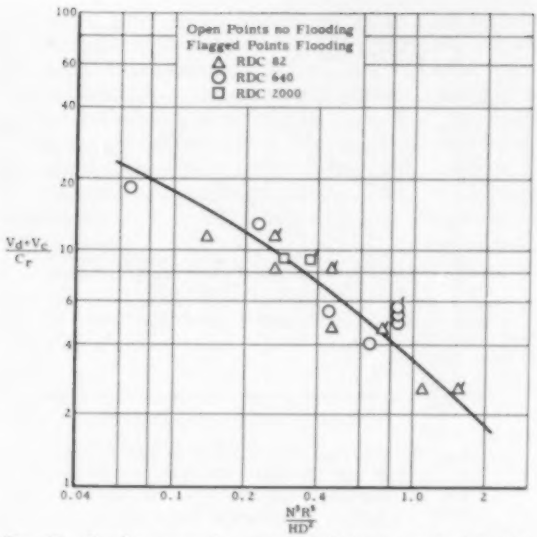


Fig. 10. Flooding curve for system: 240 S.S.U. at 140° F. lub. oil distillate, furfural, furfural continuous phase. arbitrary scales.

	RDC 82	RDC 640	RDC 2,000
D	3.2 in.	2 ft.-1 in.	6 ft.-1 in.
S	2.55 in.	1 ft.-4 in.	4 ft.-5 in.
R	2.2 in.	1 ft.-0 in.	3 ft.-4 in.
H	0.8 in.	4.7 in.	10 in.
C	75	30	20 in.

of the dispersion cannot be adequately controlled and interstage coalescence limits capacity.

In the rotating-disc contactor no interstage settling and redispersion is employed. As already mentioned, the size of the droplets formed is controlled and maintained in each compartment with the use of the appropriate rotor speed. Flat rotor discs and stator rings without any protrusions create uniform shearing conditions and aid in obtaining a small spread in droplet size. It has been found that protrusions in general give rise to high local shearing stresses and thus to the formation of a considerable amount of fine droplets which under certain circumstances reduce the capacity appreciably. The flow pattern of the liquid in the compartments is such that the desired countercurrent flow of the dispersed and continuous phase occurs. This flow of liquid consists of a rotation of the whole liquid mass on which there is superimposed a slower movement of the liquid from the shaft towards the wall of the contactor in the vicinity of the rotor discs, and from the wall back towards the shaft in the vicinity of the stator rings. Thus the resulting flow of the liquid is toroidal. In each compartment two vortices of opposite senses geared together occur and form a complete vortex.

The energy transferred from the rotor discs to the liquid creates further a rather uniform turbulence in the liquid phase and this appears to be beneficial for obtaining high mass transfer rates, that is, high efficiencies.

Results on Standard Test Systems

During the initial stages of the development, contactors ranging in size from 2 to 16 in. were tested extensively with two standard liquid systems normally used for this purpose to ascertain the influence of different variables on efficiency and capacity.

These liquid systems were (1) water-methyl isobutyl ketone (M.I.B.K.)–acetic acid, and (2) water-kerosene-*n*-butylamine.

The first system may be classed as "easy to extract" and the second one as "difficult to extract." For both systems when used at appropriate concentrations of the solute, acetic acid and *n*-butylamine, respectively, the equilibrium and operating line are sufficiently straight to allow a rapid calculation of the number of theoretical stages by the usual formulas from the concentration of the solute in the streams and the flow rates.

The influence of important variables illustrated by means of Figures 3 to 9 inclusive was found to be as follows.

1. Rotor speed. The capacity decreases with increasing rotor speed; the efficiency (stages/ft. contactor height) increases with increasing rotor speed. However, in certain cases the efficiency passes through a maximum. This phenomenon must be ascribed to backmixing in the extraction zone and has been observed also by Vermijs and Kramers (2).

2. Diameter of rotor discs. The capacity decreases and the efficiency increases with increasing diameter of the rotor discs.

3. Diameter of opening in stator rings. With increasing diameter of the opening in the stator discs the capacity increases, and the efficiency decreases.

4. Height of compartment. The capacity increases with increasing height of compartment. The efficiency is practically constant for small compartment heights, but it decreases for increasing compartment heights.

5. Diameter of shell. At constant (*R*/*D*), column diameter has little influence on specific load and efficiency.

6. Specific load. In general the efficiency increases somewhat with increasing specific load. However, under conditions that noticeable backmixing occurs, the reverse effect may occur.

7. Phase ratio. An increase of dispersed flow rate at constant continuous flow rate leads to a higher efficiency.

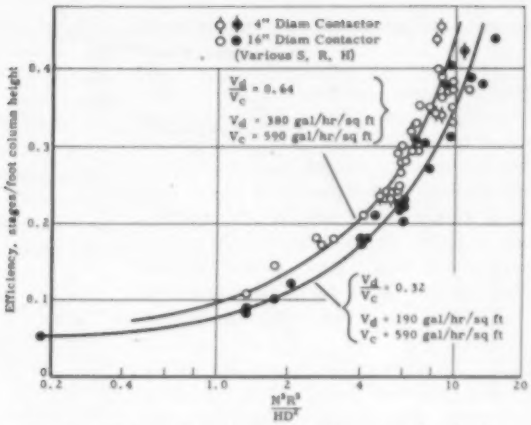


Fig. 11. Efficiency for system water—kerosene—butylamine. System water—kerosene—butylamine, water dispersed.

The effects mentioned under the last two items are characteristic of all countercurrent liquid-extraction apparatus.

Correlation of Capacity and Efficiency Data

Although useful for a preliminary estimation of the effect of various variables on capacity and efficiency, data given in the preceding section do not furnish a good basis for designing contactors. Only dimensionless correlations or correlations which can easily be reduced to dimensionless ones, will do in this respect. Hence, attempts have been made to correlate the data in this way.

It is obvious that the drop size of the dispersed phase will play a preponderant role in determining the capacity and efficiency. Therefore, the relations to be found should express this fact. Now Hinze (*1*) has shown that in a turbulent field of flow the drop size in an emulsion is determined by the energy input per unit volume of the emulsion. Starting from this concept, analysis of the problem showed the quantity N^3R^5/HD^2 to be an important variable.

In Figure 10 capacity data are given

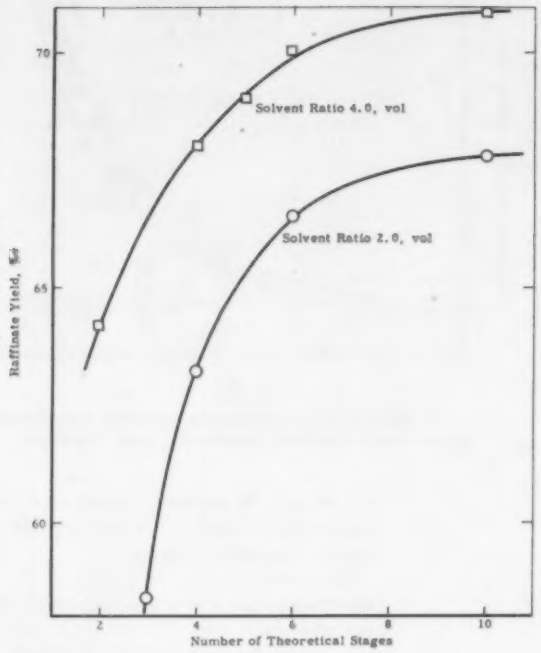


Fig. 12. Extraction of 240 S.S.U. at 140° F. lub. oil distillate with furfural. Effect of number of theoretical stages on raffinate yield for fixed raffinate quality.

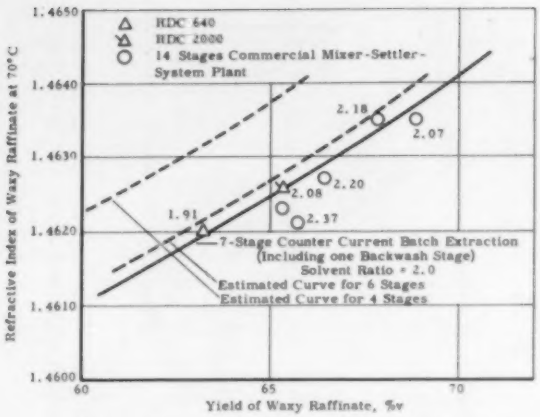

RDC 640
RDC 2000
14 Stages Commercial Mixer-Settler-System Plant
7-Stage Counter Current Batch Extraction (Including one Backwash Stage)
Solvent Ratio = 2.0
Estimated Curve for 6 Stages
Estimated Curve for 4 Stages
Refractive Index of Waxy Raffinate at 70°C
Yield of Waxy Raffinate, %v

Fig. 13. Extraction of 240 S.S.U. at 140° F. lub. oil distillate with furfural. 240 S.S.U. at 140° F. lub. oil distillate; refractive index of feed at 70° C. = 1.4910; solvent ratios indicated.

for three contactors with diameters as shown for the extraction of a 240 S.S.U. at 140° F. lubricating oil distillate with furfural. At constant phase ratio the total specific load, after correction for the restriction of the tube shell by the rotor discs and stator rings, appears to be only a function of N^3R^5/HD^2, a quantity proportional to the energy input per unit volume of liquid present in the extraction zone.

For the efficiency a similar relation holds, provided certain requirements, that is, with respect to backmixing, are fulfilled. Figure 11 illustrates the efficiency correlation obtained for two contactors, 4 and 16 in. in diam., respectively on the water-kerosene-*n*-butylamine system. It is clear from this figure that there is no loss in efficiency in scaling up from a tube diameter of 4 to 16 in. Data obtained for other liquid systems indicate the same trend, and it can be stated that in general there is no or hardly any loss in efficiency in scaling up.

As already indicated, the relations given do not hold generally, nor are they dimensionless. Both shortcomings can in principle be overcome; however, this leads to complicated relations.

Applications of the Rotating-Disc Contactor

In the authors' opinion the results obtained by testing an extraction apparatus with standard liquid systems give only a preliminary impression of the qualities of the apparatus because during these tests the conditions are too favorable. In actual practice, factors such as the presence of rags (foreign material which separates from the liquid phases during contacting) or emulsifiers often play a preponderant role. Therefore, the best test for an extraction apparatus is to perform actual extractions in it. A survey of results obtained with rotating-disc contactors of various sizes is given here.

1. Lubricating Oil Extraction with Furfural

One of the most important solvent-refining processes in the oil industry is the manufacture of high-grade lubricating oils by extraction with furfural. In Figure 12 characteristic data for this type of extraction are given. The data were obtained from equilibrium batch countercurrent extractions. They show that the solvent ratio (furfural to feed ratio) required for a given separation diminishes as the number of stages increases. In addition, it appears that seven theoretical stages are about the maximum that can be usefully applied.

Table 1.

	Rotating-Disc Contactor 640	2,000
Diameter of column	2 ft.– 1 in.	6 ft.–6 in.
Diameter of stator ring	1 ft.– 4 in.	4 ft.–5 in.
Diameter of rotor discs	1 ft.– 0 in.	3 ft.–4 in.
Compartment height	4.7 in.	10 in.
Total number of compartments	30	20
Effective height	11 ft.–10 in.	16 ft.–8 in.
Total height	15 ft.– 8 in.	22 ft.–2 in.
Rotor speed, rev./min.	60	25
Power input, hp.	$<<0.1$	<1
Operation with furfural as the continuous phase		

Table 2.

Oil	Viscosity, Saybolt Universal at 140° F. sec.	Packed column Furfural rate gal./(hr.)(sq.ft.)	Packed column Solvent ratio	R.D.C. Furfural rate gal./(hr.)(sq.ft.)	R.D.C. Solvent ratio
Spindle	56	360	2.0	550	2.0
Medium machine	285	480	3.0	550	2.0
Deasphalted residue	800	315	4.5	550	3.4

There is little to be gained by using more than seven stages; however, decreasing the number of stages below seven soon leads to appreciably poorer extraction results. From an extraction point of view apparatus having seven or slightly more than seven theoretical stages must be considered ideal for the extraction of lubricating oil with furfural.

Up to the present the multistage mixer-settler system has been one of the few practical devices to realize seven theoretical stages on a commercial scale. Shell installed such a system consisting of fourteen actual stages in one of its first furfural plants. However, owing to the drawbacks of the system—it is costly to build and operate—it has been preferable in most cases to use packed columns. With the packed column, however, it is difficult to attain the desired seven theoretical stages even when using columns as high as 100 ft. Moreover, the packed column has poor flexibility. The efficiency drops considerably when the load on the column is decreased. In actual practice a packed column may be considered to have four to six theoretical stages for the extraction of lubricating oils with furfural.

With the advent of the rotating-disc contactor, an evaluation of this apparatus was made for lubricating oil extraction. The contactor was found to be ideally suited for it. High efficiencies at high specific loads can easily be obtained. Figure 13 gives data on the separating power of two rotating-disc contactors when operating on a medium machine oil distillate. Data for the fourteen-stage commercial mixer-settler system plant mentioned before have been included in the graph. Technical data for the contactors are shown in Table 1.

The contactors were provided with an external bottom settler where the furfural phase leaving the contactor settles for about 10 min. The settler was used as a backwash (reflux) stage. Variation of the total specific load on the contactor from 200 to 800 gal./(hr.)(sq.ft.) did not influence the separating power. For other oils ranging from spindle oil to deasphalted oil similar results have been found.

The contactor mentioned, R.D.C. 2,000, has been found to give the same or even a better extraction, depending on conditions, than a commercial packed column more than 100 ft. high. Moreover, allowable specific load is, if anything, rather higher in the case of the rotating-disc contactor (see Table 2).

Here it will be noted that the solvent ratios applied for the packed column are generally higher than for the rotating-disc contactor. This is related to the lower efficiency of the packed column as compared with the rotating-disc contactor.

At present four contactors are in successful commercial operation for the extraction of lubricating oils with furfural. One of them, 6 ft.-6 in. diam. and 24 ft. high (see Figure 14), has replaced the multistage mixer-settler system previously mentioned. The cost of this contactor is estimated to be less than 50% of the mixer-settler system. Furthermore, the holdup of the valuable solvent in the contactor is about 10% of that in the mixer-settler system and unavoidable solvent losses are reduced by about 30%. A rotating-disc contactor doing the same or even better job than a packed column of more than 100 ft. high in lubricating oil extraction has a cost only 30 to 40% of that of the packed column.

Table 3.

Diameter of column	24 in.
Diameter of stator ring	18 in.
Diameter of rotor disc	15 in.
Height of compartment	7 in.
Number of compartments	16
Height of settler: bottom	4 ft.
top	4 ft., 6 in.
Total height of column	18 ft.

Table 4.

Run	Rotor speed, rev./min.	Flows, gal./min. Feed	Solvent	Solvent/ feed	% w Extracted from feed A	% w Extracted from feed B	Efficiency stages/ft. A	Efficiency stages/ft. B
1	0	3.1	29.2	9.4	46.7	85.9	0.14	0.15
2	160	3.1	29.0	9.4	53.9	90.3	0.19	0.19
3	200	3.1	30.0	9.7	66.3	97.8	0.36	0.31
4	300	3.1	30.0	9.7	....	97.9	....	0.31
5	400	3.1	30.0	9.7	68.4	97.8	0.41	0.31
6	250	1.8	10.4	5.8	46.5	94.0	*	0.33
7	250	2.7	15.0	5.6	46.0	94.5	*	0.36
8	250	3.6	19.6	5.5	43.1	96.7	*	0.45
9	250	4.0	22.0	5.5	46.6	98.4	*	0.55
10	250	2.0	10.0	5.0	41.0	91.2	*	0.33
11	250	2.0	20.0	10.0	75.0	97.3	0.65	0.27
12	250	2.0	30.0	15.0	90.8	99.0	0.57	0.27

* Pinch region, small extraction factor; the number of stages cannot be calculated sufficiently accurately. $K_A = 0.080$
$K_B = 0.350$ Predisperser used for feed.

2. Extraction of a Mixed Chlorinated Hydrocarbon Feed

At present a rotating-disc contactor is being employed in one of Shell's chemical plants for the extraction of a mixed chlorinated hydrocarbon feed. Two components, designated here as A and B, are extracted from this feed. The system may be classified as one difficult to extract in terms of high density difference and interfacial tension. Table 3 gives dimensions of the contactor used and Table 4 shows results obtained during test runs.

The efficiencies obtained fall in the same range as those for the system water-kerosene- n-butylamine. Runs 1-5 show that rotor speed, other variables constant, has some effect on the efficiency. However, it is less than might be expected on the basis of data for other systems. This, plus the relatively good efficiency at zero rotor speed (run 1), may mean that the feed predisperser contributes significantly to the tower efficiency at lower rotor speed. Runs 6-9 show that an increase in total flow rate (constant solvent ratio) improves the efficiency. The effect is slightly more pronounced than for the system M.I.B.K.-water-acetic acid as shown in Figure 3. Runs 10-12 show that the efficiency decreases slightly as the solvent ratio is increased. As regards capacity, run 5 was close to flooding.

3. Extraction of Mercaptans from Gasoline Fractions

Extraction of mercaptans from gasoline fractions for quality improvement is a well-known refining operation. Depending on the boiling range of the fraction to be treated, either caustic solution or Solutizer solution* is used as a solvent.

These extractions are characterized by the difficulty of obtaining high extraction efficiencies. The reasons for this will be clear from the list (see Table 5) in which the most important physical properties of the liquid systems are given.

Packed towers of considerable height often have been found to be equivalent to no more than one theoretical stage for this service. The mixer-settler system, being more reliable from the point of view of efficiency, therefore, has found general application for the treating of gasoline fractions with caustic- and Solutizer

* Solutizer solution is an aqueous solution of potassium hydroxide and alkylphenols.

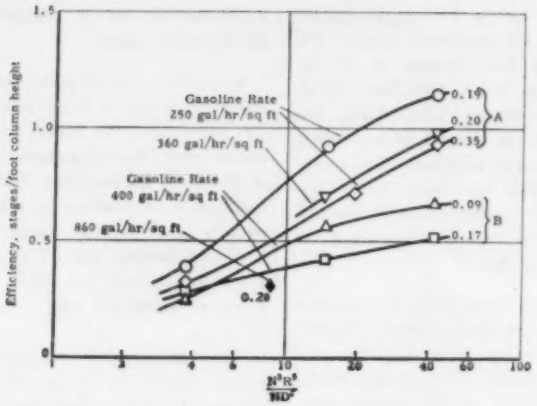


Fig. 15. Efficiency for caustic and Solutizer extraction in two contactors (for dimensions, see Fig. 10)
Gasoline—continuous phase, solvent ratios indicated.
A—caustic extraction } lab. contactor *RDC* 82
B—Solutizer extraction }
◆ —semicommercial unit—*RDC* 640

solution. However, this equipment does not give complete satisfaction either. It is costly to build, hence only four actual stages, which are equivalent to about two to three theoretical stages, are usually provided for, whereas from an economic point of view extraction equipment equivalent to five theoretical stages would be desirable. With this last point in mind the rotating-disc contactor has been evaluated for the treatment of gasolines with caustic- and Solutizer solution.

Caustic- and Solutizer extraction have both been studied on a laboratory scale; Solutizer extraction has been studied also on a semicommercial scale. Favorable results have been obtained as may be seen from Figure 15. In the laboratory study *n*-butyl mercaptan was used as the solute for the caustic extractions, *n*-octyl mercaptan for the Solutizer extractions. Use of these pure compounds enabled a rapid determination of the efficiency by straightforward calculation. The semicommercial scale work was done with actual plant streams and the efficiency had to be established by carrying out comparative equilibrium batch extractions.

The data given show that:

1. The efficiency increases with increasing rotor speed.
2. At constant gasoline rate the efficiency increases with decreasing solvent ratio.
3. The efficiency decreases with increasing load.

Efficiencies for the caustic extraction are higher than for the Solutizer extraction, which probably has to be explained by assuming that the effect of high interfacial tension is less detrimental for mass transfer than high viscosity of the dispersed phase. The efficiency obtained in the semicommercial test for Solutizer extraction is slightly lower than in the laboratory tests. The explanation for this may be found in the slight differences in Solutizer properties. Certainly the conclusion can be stated that there is no, or hardly any, loss in efficiency in scaling up.

The value of 0.3 stages/foot of column height can be assumed also to be representative of commercial-scale contactors, and hence it appears that with the rotating-disc contactor the desired five theoretical stages will easily be attained. It is expected, therefore, that before long the contactor will be applied for caustic- and Solutizer extraction on a commercial scale.

4. Purification of Synthetic Detergent Solution

The manufacture of certain synthetic detergents comprises an extraction step in which the reaction mixture is freed from, for example, unreacted hydrocarbons, polymerized hydrocarbons, and higher alcohols by extracting the solution with a low-boiling gasoline fraction.

Sometimes difficulties are encountered because of the strong tendency of the liquid system involved to form a gel-like relative stable emulsion. Moreover, the interfacial tension of the synthetic detergent solution gasoline system is very low (less than 1 dyne/cm). Experiments carried out in rotating-disc contactors ranging in diameter from 2.5 in. to 2.1 ft. showed that by choosing the appropriate (rather low) rotor speeds it was possible to overcome all emulsification troubles. The detergent solution was the dispersed phase during these experiments.

The extraction results were favorable. It was found that a single rotating-disc contactor of 4 ft.-9 in. diam., and a total height of 17 ft. could replace two packed columns, each 4 ft. in diam. and 70 ft. high in the purification of 75 ton/day crude detergent solution. The erected cost of the contactor was 45% of that of the two packed columns.

After this review of data it appears justified to conclude that with the rotating disc contactor a highly efficient, flexible, low cost extraction apparatus has become available for capacity requirements ranging from several hundred tons per day to fractions of a ton per day.

The Lummus Company and the Turbo-Mixer Division of General American Transportation Corporation, both of New York, have been authorized to engineer and build rotating disc contactors.

Table 5.

	Caustic solution	Solutizer solution
Interfacial tension, dynes/cm.	~30*	2–3
Viscosity, centipoise	< 2	20–30*
Density difference, lb./cu.ft.	19*	30–40*

* Properties which are responsible for the difficult extraction behavior of the systems.

Acknowledgment

The authors wish to thank the management of The N. V. De Bataafsche Petroleum Maatschappij, The Hague, Netherlands, and Shell Development Company, Emeryville, for permission to publish the above description and acknowledge with full appreciation the assistance of those who cooperated in the work.

Notation

D = diameter of column
S = diameter of stator ring
R = diameter of rotor disc
H = compartment height
C = number of compartments
N = rotor speed, rev./time
v_d = superficial velocity of dispersed phase
v_c = superficial velocity of continuous phase
C_R = factor which accounts for the restriction of the column by the stator rings and rotor discs in capacity correlation
K = solute distribution ratio, (g.)/(g. solvent)/(g.)/(g. feed)

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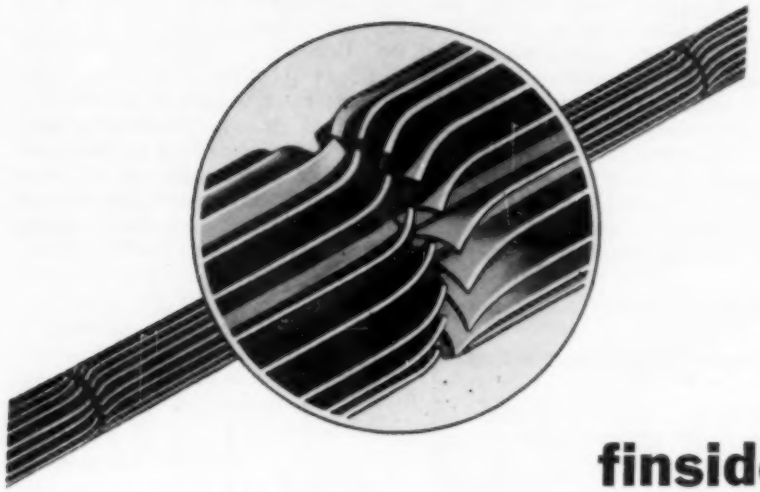
1. Hinze, J. O., in press.
2. Vermijs, H. J. A., and H. A. Kramers, *Chem. Eng. Sci.*, **3**, 55-64 (1954).

Presented at A.I.Ch.E. 47th annual meeting, New York.

Fig. 3. Close-up view of finned-tube, showing cut-and-twist construction.



CALCULATION OF

finside coefficients

IN LONGITUDINAL

finned – tube exchangers

Loyal Clarke and R. E. Winston

Day & Zimmermann, Inc., Philadelphia, Pennsylvania

Theoretical Background

Various workers have developed sound methods for the calculation of heat transfer to fluids in pipes. These treatments were based on the theory of similarity and dimensional analysis so that through experimental procedure the basic equations and their constants could be established by experimental results.

The most commonly used equations for flow—both turbulent and streamline—are those of Sieder and Tate (*9*). They are

TURBULENT FLOW

$$j = S_t P_r^{2/3} \left(\frac{\mu_s}{\mu}\right)^{0.14} = \frac{0.027}{R_e^{0.2}} \qquad (1)$$

STREAMLINE FLOW

$$j = S_t P_r^{2/3} \left(\frac{\mu_s}{\mu}\right)^{0.14} = \frac{1.86}{R_e^{1/3}} \left(\frac{D}{L}\right)^{1/3} \qquad (2)$$

For straight pipes the streamline equation applies when the Reynolds number is less than the lower critical value, which is usually taken as 2,100, though many authorities use 2,000. The turbulent equation applies for Reynolds numbers greater than 10,000.

For Reynolds values between 2,100 and 10,000 the heat transfer is intermediate between that given by Equations (1) and (2). For lack of a better term, this range is usually called the transition range, even though it is broader than the transition range of 2,100 to 3,000 between streamline and turbulent flow as deduced from pressure drop data above. The Sieder and Tate Chart (*9*) is perhaps the most widely used method of treating the transition range.

Both common sense and theoretical considerations lead to the belief that correlation of heat exchange in annular spaces should be closely similar to the correlations of tube data though two differences are apparent. An annulus has no unique physical dimension corresponding exactly to the pipe diameter, and only a portion of the total wetted surface is heated (or cooled) in the usual commercial double-pipe or finned-tube exchangers. Another difference, which is evident on a closer study, is the lack of geometric similarity between the surface of the inner pipe, the fins, and the outer pipe.

The simplest generalization for applying heat transfer data in tubes to other types of surfaces is to replace the diameter by an equivalent diameter. Two

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such equivalent diameters have been proposed.

EQUIVALENT DIAMETER

$$D_e = \frac{4 \times \text{flow area}}{\text{wetter perimeter}} \qquad (3)$$

NUSSELT DIAMETER

$$D_n = \frac{4 \times \text{flow area}}{\text{heated (or cooled) perimeter}} \qquad (4)$$

flow. For example, if one computes the film coefficient by Equation (1) for turbulent flow, the result will be incorrect if the actual flow is streamline.

Unfortunatley, the Reynolds number computed from the equivalent diameter does not accurately predict the type of flow in either double-pipe or finned-tube annuli. Streamline flow equations fail at Reynolds numbers well below the critical value for tubes of 2,000 to 2,100. The discrepancy is less if the Nusselt diameter is used, but this diameter is not known to have hydraulic significance.

Thus it would appear that complete knowledge of the conditions that determine the type of flow are not presently available. Until such facts are known, a precise analysis for the entire flow range cannot be made. To put it another way: even if equations applying accurately to streamline and turbulent conditions are established, one's knowledge of the transition zone will suffer to some extent because it is not known where this zone is.

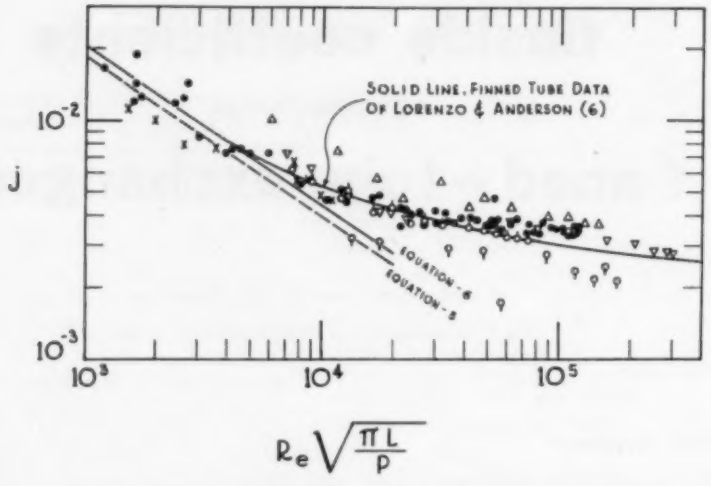

Fig. 1. Correlation of film coefficients of heat transfer in narrow annuli and finned-tube shells.

	Reference	Annulus	$\pi L/D$	D_2/D_1
●	Carpenter et al. (1)	cooled	66	1.33
○	McMillen & Larson (7)	heated	36.7	1.25
○	ibid.	cooled	36.7	1.25
△	ibid.	heated	54.2	1.37
▽	ibid.	cooled	54.2	1.37
×	Chen et al. (2)	cooled	28.4	1.375

This expedient, with the use of either D_e or D_n, does afford a practical first approximation for the calculation of heat transfer coefficients in double pipe and finned-tube annuli. Actually neither the use of the equivalent diameter nor of the Nusselt diameter permits a comprehensive correlation of the desired accuracy.

In order that completely adequate correlations can be secured, one must know whether any given flow rate is in the streamline, turbulent, or transition range. This is due to the fact that the heat transfer relations depend on the type of

For the streamline range where Equation (2) applies, it should be noted that the diameter appears twice—in the Reynolds number and in the D/L factor. Carpenter, Colburn and Schoenborn (*1*) point out that if the equivalent diameter is used in the Reynolds number, it does not necessarily apply to the D/L term. These above-mentioned authors suggest that this term be replaced by $(D_1 + D_2)/L$ for annuli. Such substitutions into Equation (2) lead to

$$j = 1.86\left(\frac{D_e G}{\mu}\right)^{-2/3}\left(\frac{D_1 + D_2}{L}\right)^{1/3}$$

or

$$j = 1.86\left(\frac{D_e G}{\mu}\right)^{-2/3}\left(\frac{P}{\pi L}\right)^{1/3} \qquad (5)$$

The term, $P/\pi\ L$, is identical with $(D_1 + D_2)/L$ for double-pipe annuli but the term is in a form that allows application of the same equation to finned-tube exchangers. In this case the annulus closely approaches a series of channels, at least for available commercial units in which the fins extend almost to the outer shell. Thus P is here defined as the average perimeter of these channels (total perimeter of all fins, exposed portions of inner pipe, and outer pipe divided by the number of fins).

Correlation of Experimental Data

The correlation discussed here is based on Equation (5) and on its empirical extension into the transition zone.

Equation (5) can be rearranged to the alternate form given below:

$$j = 1.86\left[\frac{D_e G}{\mu}\left(\frac{\pi L}{P}\right)^{1/2}\right]^{-2/3} \qquad (5A)$$

If this equation is correct, the streamline data should fall on a single line when the j-factor is plotted on log-log paper against the term

$$\frac{D_e G}{\mu}\left(\frac{\pi L}{P}\right)^{1/3}$$

Figure 1 presents such a plot of the available data for narrow annuli (*1, 2, 7*). The solid line is drawn to agree with a plot of recommended curves for finned tubes (*6*). This correlation of data is good for the region covered which extends into the turbulent range since the scattering of the points is probably no more than that which results from experimental inaccuracies. For example, the data of McMillen and Larson (*7*) for cooled and heated annuli differ considerably. The agreement is surprising since this method of plot-

ting is not known to have a definite theoretical basis except for streamline flow. It is hoped that this empirical observation may aid the future development of more comprehensive correlations having a theoretical basis.

Data for wider annuli (*2, 5, 7*), having diameter ratios (D_1/D_2) greater than 1.4 are not included in Figure 1 because their agreement with the correlation is only fair. Specifically, a similar plot of these data scatters and shows a trend toward higher values of j at higher D_1/D_2 ratios. Inclusion of a diameter ratio term would probably permit extension to wider annuli; however this would have no significance for finned-tube exchangers.

Table 1.—Data of Gunter and Shaw (4)

Length of Fins, ft.				
Total	Between Cuts	R_e		
L	L_e	$\frac{D_e G}{\mu}$	j	$jR_e^{2/3}\left(\frac{(\pi L_e)}{(P)}\right)^{1/2}$
10	10	23.4	0.028	1.87
5	5	23.4	0.035	1.86
10	2.45	23.4	0.044	1.85
10	1.2	23.4	0.056	1.85

Recommended Procedure

The straight portion of Figure 1 applying to streamline flow is represented by Equation (6).

$$j = 2.07\, R_e^{-2/3}\left(\frac{\pi L}{P}\right)^{1/6} \qquad (6)$$

At least some of the heat transfer in the measurements resulted from the contribution of free thermal convection (*1, 2, 3*). The effect of thermal convection is dependent on a large number of factors and can be estimated by several methods such as that proposed by Colburn (*3*). The net effect of free convection in streamline flow is smaller for viscous than for thin liquids.

Unless free convection is specifically estimated, little credit should be assumed, and, therefore the more conservative Equation (*5*) proposed by Carpenter, Colburn and Schoenborn (*1*) is recommended in place of Equation (6).

Figure 2 presents the recommended correlation obtained from Figure 1 as just noted. Because the basis of this graph is empirical, it is necessary to define the conditions for which it is recommended.

These are

1. **All finned-tube exchangers now commercially available, except cut and twist in the transition and turbulent range.**
2. **Double-pipe exchangers with narrow annuli (D_1/D_2) below 1.4, providing inner pipe, are no larger than 2½ in.**

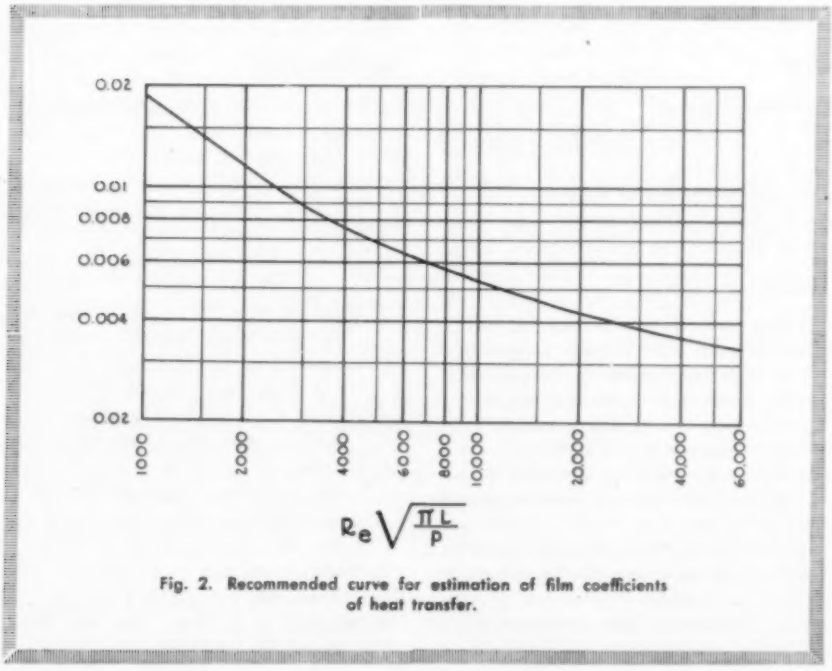

Fig. 2. Recommended curve for estimation of film coefficients of heat transfer.

For high flow rates above the range of the figure, the Sieder-Tate equation (repeated below) can be used in the absence of more complete information.

$$j = \frac{0.027}{R_e^{0.2}}$$

For wide annuli and turbulent flow the equation of Wiegand (*10*) is suggested. For narrow annuli of large diameter and streamline flow, the equations given by Norris & Streid (*8*)

can be employed. These relations are rigorous for flow between two parallel plates. When only one surface is heated, higher coefficients (perhaps 25 per cent higher) are expected, hence this method affords a conservative estimate.

Cut and Twist Finned Tubes

Manufacturers of finned-tube exchangers offer cut and twist units (see Figure 3). In this arrangement the length of the fins is the length between cuts. The twist provides a directional change of flow and a corresponding local turbulence which would be expected to mix the fluid and thereby shorten the effective length for heat transfer. The principal application of this construction is to improve heat transfer in units operating in the streamline range.

Gunter and Shaw (*4*) present data on such units corrected to a Reynolds number of 23.4. The applicable portion of their data is shown in Table 1. Agreement with Equation (5) is excellent when the total length, L, is replaced by the distance between cuts, L_e.

Thus Equation (5) or Figure 2 can be used for cut and twist exchangers

Table 2.—Data on Longitudinal Finned-Tube Exchangers

Mfr. (*)	Type	Outer Pipe I.P.S.	Inner Pipe Size, in. O.D.	Inner Pipe Size, in. I.D.	Inner Pipe Flow Area sq.in.	Fins No.	Fins Thickness in.	Fins Height in.	Annulus Flow Area sq.in.	Annulus A_o/L ft. (‡)	Annulus Hydraulic Equiv. Diam. in.	Annulus P, (‡) ft.	Annulus (‡) A_o/Ai
BFT	CA	1½	0.500	0.370	0.1076	12	0.035	0.5	1.61	1.13	0.346	0.130	11.7
BFT	EE–12	2	1.000	0.782	0.4803	12	0.035	0.5	2.34	1.26	0.434	0.150	6.16
BFT	EE–16	2	1.000	0.782	0.4803	16	0.035	0.5	2.27	1.60	0.354	0.133	7.8
BFT	EE–20	2	1.000	0.782	0.4803	20	0.035	0.5	2.19	1.93	0.295	0.124	9.4
G-R	A&B	2½	1.050	0.825	0.533	18	0.024	0.5	3.71	1.77	0.511	0.134	8.22
G-R	A&B 5	2½	1.050	0.825	0.533	18	0.024	0.625	3.652	2.150	0.435	0.155	9.97
BFT	JE–12	3	1.000	0.782	0.4803	12	0.035	1.0	6.17	2.27	0.671	0.256	11.0
BFT	JE–16	3	1.000	0.782	0.4803	16	0.035	1.0	6.02	2.94	0.540	0.234	14.3
BFT	JE–20	3	1.000	0.782	0.4803	20	0.035	1.0	5.88	3.60	0.446	0.221	17.6
G-R	C6S	3	1.900	1.610	2.036	16	0.050	0.5	4.16	1.83	0.526	0.164	4.36
G-R	C&D	3	1.900	1.610	2.036	24	0.024	0.5	4.27	2.50	0.43	0.138	5.93
BFT	JH24	3	1.900	1.610	2.036	24	0.035	0.5	4.10	2.50	0.415	0.138	5.93
BFT	JH24(†)	3	1.900	1.610	2.036	24	0.050	0.5	3.91	2.50	0.395	0.138	5.93
BFT	JH28	3	1.900	1.610	2.036	28	0.035	0.5	4.03	2.83	0.37	0.130	6.72
BFT	JH28(†)	3	1.900	1.610	2.036	28	0.050	0.5	3.81	2.83	0.349	0.130	6.72
G-R	C2S	3	1.900	1.610	2.036	32	0.024	0.5	4.17	3.17	0.351	0.124	7.53
BFT	JH36	3	1.900	1.610	2.036	36	0.035	0.5	3.88	3.50	0.301	0.120	8.3
G-R	L&M	3½	1.900	1.610	2.036	16	0.050	0.735	6.46	2.46	0.637	0.212	5.82
BFT	LH24	3½	1.900	1.610	2.036	24	0.035	0.75	6.39	3.50	0.48	0.185	8.29
BFT	LH24(†)	3½	1.900	1.610	2.036	24	0.050	0.75	6.10	3.50	0.459	0.185	8.29
BFT	LH28	3½	1.900	1.610	2.036	28	0.035	0.75	6.28	4.00	0.425	0.176	9.48
BFT	LH28(†)	3½	1.900	1.610	2.036	28	0.050	0.75	5.95	4.00	0.403	0.176	9.48
G-R	L&M 2	3½	1.900	1.610	2.036	32	0.050	0.75	5.88	4.415	0.367	0.167	10.51
BFT	NH24	4	1.900	1.610	2.036	24	0.035	1.0	9.02	4.50	0.541	0.231	10.65
BFT	NH24(†)	4	1.900	1.610	2.036	24	0.050	1.0	8.65	4.50	0.52	0.231	10.65
BFT	NH28	4	1.900	1.610	2.036	28	0.035	1.0	8.88	5.16	0.475	0.222	12.25
BFT	NH28(†)	4	1.900	1.610	2.036	28	0.050	1.0	8.44	5.16	0.451	0.222	12.25

* BFT, Brown Fintube—G-R, Griscom Russell (listing does not include all types manufactured).

† Thick fins used in aluminum exchangers (and steel on special request, thickness of 0.024 also available on request).

‡ A_o = Total heat transfer area of annulus, A_i = inside area of inner tube, L = total finned length, P = total wetted perimeter of annulus divided by number of channels (no. of fins).

operating in the streamline range. Probably use of Figure 2 for the transition flow would lead to some loss of accuracy. This is relatively unimportant since cut and twist exchangers are generally employed only for streamline flow.

Dimensions for Finned-Tube Exchangers

Table 2 gives data on the more common sizes of commercial double-pipe exchangers in which the center pipe has external-longitudinal fins.

Acknowledgment

Permission of two Ohio companies, namely the Griscom-Russell Company, Massillon, and the Brown Fintube Company, Elyria, to publish dimensional data on exchangers manufactured by them is acknowledged.

Thanks are due Rupen Eksergian, Francis L. Jackson, and K. A. Gardner for their constructive suggestions.

Notation

Dimensionless groups:

$j = S_t P_r^{2/3}(\mu_s/\mu)^{0.14}$—modified Colburn j-factor

$S_t = h/c_p G$, Stanton number

$P_r = c_p\mu/k$, Prandtl number

$R_e = D_e G/\mu$, Reynolds number

Dimensional quantities:

D = inside diameter of pipe, ft.

D_1, D_2 = outer, inner diameter of annulus, ft.

D_e = hydraulic equivalent diameter, ft.

D_n = Nusselt equivalent diameter, ft.

G = mass velocity (lb./(hr.)(sq.ft.)

L = length of heated section, ft.

P = wetted perimeter of channel, ft.

c_p = specific heat at constant pressure, B.t.u./(lb.)(° F.)

h = film coefficient, B.t.u./(hr.)(sq.ft.)(° F.)

k = thermal conductivity, B.t.u./(hr.)(sq.ft.)(° F./ft.)

μ, μ_s = viscosity at bulk, surface temperature (lb.)/(ft.)(hr.)

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the meaning of ORGANIZATION

Various types of company organization are compared and analyzed as to their suitability to meet particular needs.—*Editor*

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Cresap, McCormick, and Paget
New York

This paper presents the principles and practices that underlie business organization and organizational planning. It concentrates on boiling down the theory and philosophy of organization to certain practical concepts that are applied every day by those who work intensively in organizational planning.

In business today, the word organization usually brings up visions of an organizational chart with boxes and lines neatly and symmetrically arranged. However, all too often it is not realized that such charts are much like a flow diagram of a chemical process, that is, a tremendous amount of thinking, analyzing, and planning must be done with certain key principles in mind before the diagram can be drawn. It is with those key principles, which might be called the Boyle's, Charles', and Dalton's laws of organization, that this paper is concerned.

There are three basic types of organization—functional, product, and regional.

Functional Organization

The functional type of organization is the simplest and, one might say the most elemental, because it is applied with great frequency not only to large and small companies, but also to the subdivisions of large corporations, the over-all pattern of which may be developed along other lines.

This functional type is illustrated in an organizational plan of a small chemical and pharmaceutical company as it existed a few years ago (Figure 1). In this case the activities of the company were organized under five functional groupings, each under the supervision of a key executive reporting to the executive vice-president.

The functional type is most appropriate, especially where it is desired to achieve close coordination of all activities related to one or a small number of products or services. In the chemical and pharmaceutical company referred to, the centralization of responsibility in the executive vice-president makes it possible to direct and supervise complex development, production, and marketing in a field where today's product may be tomorrow's history.

In manufacturing a limited number of closely allied products, the company's activities can be rather simply organized on the basis of sales, production, engineering, and finance since these functions apply to all products. However, where there is a large number of products, or where groups of products are not related to one another from a manufacturing or marketing standpoint, this type of organization is generally not appropriate.

Another aspect of a functional organizational plan is the heavy burden it places on the president or executive vice-president. For instance, under the organization mentioned here, no major matter involving more than one functional area can be settled at a level lower than the executive vice-president.

Then too, there is only a limited opportunity to develop well-rounded executives who have acquired familiarity with the basic operations of the com-

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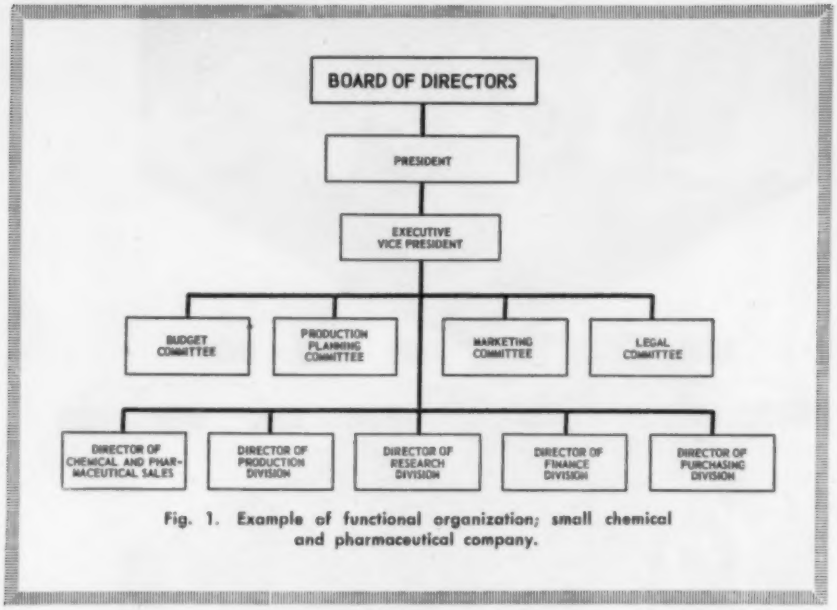


Fig. 1. Example of functional organization; small chemical and pharmaceutical company.

pany as a whole. Practically all executives develop within individual functions.

Product Organization

The second basic type of organization, namely the product organization is illustrated in Figure 2. In this type of organization, in addition to a functional staff group, the company (Koppers) is basically organized into operating divisions and subsidiaries in the form of product groups. Thus, there is a chemical group, gas and coke group, tar-products group, wood-preserving group, metal-products group, and an engineering and construction group.

The most outstanding characteristic of the product organization is that it effects the decentralization of responsibility for results. For example, under the Koppers organizational arrangement, the executive vice-president is able to delegate to the executive in charge of each of the product groups complete responsibility for performance, and each is given authority over the activities which contribute to performance. Such a decentralization of responsibilities is not possible under the functional form of organization since no function can be held responsible for the over-all performance of the company.

Also, from a product complexity point of view, the product form of organization is particularly appropriate in the case of companies with diverse product lines.

Again this form lessens the burden on top management compared with the case of the functional form of organization. Basic decisions can be made at the level of product executives. To provide coordination, the product form of organization usually requires the superimposition of a functional staff. This is shown in Koppers (Figure 2), in which a sizable group of staff divisions is provided to assure coordination among the operating divisions. Without such coordination the operating divisions might develop conflicting policies and they might not fully enjoy the benefits of their association.

And last a very important feature of the product form of organization is that it tends to develop well-rounded executives.

Regional Organization

The third or regional form of organization, illustrated in Figure 3, shows the basic activities of a large oil company and their assignment to six divitions on a regional basis.

The following aspects are worth noting.

First this regional form is most appropriate in companies where operations are scattered geographically and where those in given locations are largely self-contained. For example, in the case of the oil company, operations are located in six geographical areas of the United States. The activities in these six locations tend to be self-contained. Obviously then this form is not appropriate where the activities existing in a given area are not mainly self-contained or independent. As in the case of the product form, the regional form supplies an effective basis for decentralization, provided it is soundly conceived. Also, as in the product form of organization, functional coordination must be applied. This is exemplified in the oil company chart by the inclusion of a series of general office departments which coordinate all the functions of the company among the several regional divisions. Again as in the case of the product form of organization, the regional form of organization develops well-rounded executives. Regional executives are concerned with all functions and are trained in carrying the responsibility for profit performance.

Essentials of Organizational Planning

What are the principles that determine for any given company what the form should be and how the mechanism itself should work? There are thirteen key principles which can be grouped or classified under three headings or essentials of good organization. These three are: (1) a thorough definition of company objectives, (2) a full and careful spelling out of individual and group responsibilities and authorities, and (3) a clear defining of reporting relationships, i.e., the chain of command.

The first essential, defining company objectives, simply means a clear-cut conception of the purpose or purposes for which the organization exists. An attempt to design organization without such knowledge is comparable to an attempt to design a chemical process plant without the knowledge of the purpose for which the plant exists, the requirements involved in terms of production rates, or the condition of the end product desired.

The second essential, namely defining individual and group responsibilities and authorities, points up one of the principal deficiencies in organization—the failure to assign responsibilities, and clarify authority even in the case of key executives. Failure to define responsibilities leads to all sorts of organizational problems and confusion. The individual executive may not know exactly what his superiors expect of him, and his superiors may assume that certain activities are being covered, which are not.

A well-developed organization manual is the most practical way of assuring that the company's organization is well defined and that the responsibilities of all concerned are understood both to themselves and to others. This principle stipulates also that authority should be clearly defined, should be commensurate with assigned duties and responsibilities, and should be delegated to the lowest practical organizational level. At the same time however, it must be understood that superior executive control over subordinates must be exercised at

all management levels. If subordinate personnel are familiar with the company's policies and if they are subject to adherence to a budget, they are in a position to make decisions which are not inconsistent with top management objectives. It is not the role of top management, except in the smallest companies, to deal in the details of the company's operations, or to support weak executives by assuming the partial burden of their activities.

Obvious as it may seem duplicating, overlapping, and conflicting functions are quite common in many organizations today, especially in large-scale ones, and of course such should be eliminated.

Under another essential, that of defining reporting relationships, the end result of which is usually an organization chart, six principles should be observed.

a. Each person should know to whom he reports and who reports to him. Simple as it sounds, it is a fairly common occurrence in the organization of even well-managed companies to find a considerable amount of misunderstanding of this point. A clear-cut and detailed chart of organization, made available to all persons within the company, is the most practical means of clearing up the misunderstandings of this type.

b. No person should report to more than one supervisor. This principle here refers solely to line or operating relationships and not to staff relationships.

c. An excessive number of persons should not report directly to any supervisor. Contrary to some opinions, there is no flat rule that can be made as to the number of people that can be supervised by one executive. The guiding factor in making such a determination is the difficulty of the type of supervision involved. If individuals are engaged in routine work, it is possible to extend the span of control to include a large number. On the other hand, the head of a research laboratory consisting of scientists engaged in complex and difficult assignments may not be able to direct properly the activities of more than three subordinates. In measuring the supervisory load of an executive, consideration must be given to the amount of staff assistance with which he is provided.

d. Related functions should be grouped; unrelated functions should be separated. Failure to group related functions creates the need for a high degree of coordination, which would be automatically achieved if the functions were properly grouped. Conversely, the grouping of unrelated functions creates diffusion of efforts on the part of subordinate executives. By being assigned unrelated activities, these personnel are hampered by the diversity of their supervisory tasks and lose the benefits of specialization and the intensity of effort that is developed if their jobs were more homogeneous.

e. Overelaborate organization should be avoided. In applying the principles of organization, it is always possible to evolve a plan of organization which is complete and sound but which may be excessively expensive. Every organization plan must be evaluated carefully in the light of the size of the company and its financial abilities. If excessive expense is involved, the plan should be modified by the consolidation of units and departments and by consideration of the elimination of some activities that may not be completely essential to the success of the enterprise.

f. Consistent patterns of organization should be used at all levels. Many organizations, and most large ones, subdivide their activities into several elements on a product or regional basis. Where these elements are performing the same or a closely similar group of activities, they should be organized similarly except where there is a strong reason not to do so.

Uniformity of organization possesses three strong advantages: (1) it is simpler, (2) top staff supervision of the subordinates' elements is made easier, and (3) it assists in the development of executive personnel and facilitates the interchange of personnel without difficult transition.

These thirteen principles of practical organizational planning just described are all basic and relatively clear-cut. However, there are other aspects of organizational planning where the principle cannot be defined as readily and where judgment and experience can play an important part. A brief comment on some of these other areas follows.

ORGANIZATIONAL PLANNING

1. Problem of Personnel

In discussing organization the question always comes up whether organization should be planned according to the peculiarities of individuals in a given company, or whether an attempt should be made to fit the individuals into the plan.

Actually, it is impractical and unrealistic to attempt to do either rigidly; the best course is a compromise between the two, but always with the ideal in mind. This subject has been treated practically and with a touch of humor (1).

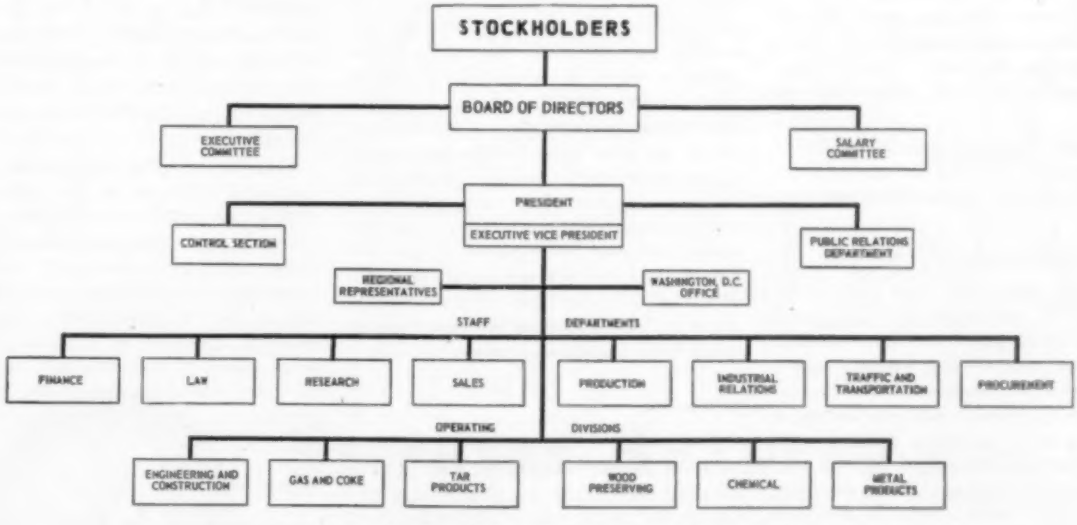


Fig. 2. Example of product organization; Koppers Company, Inc.

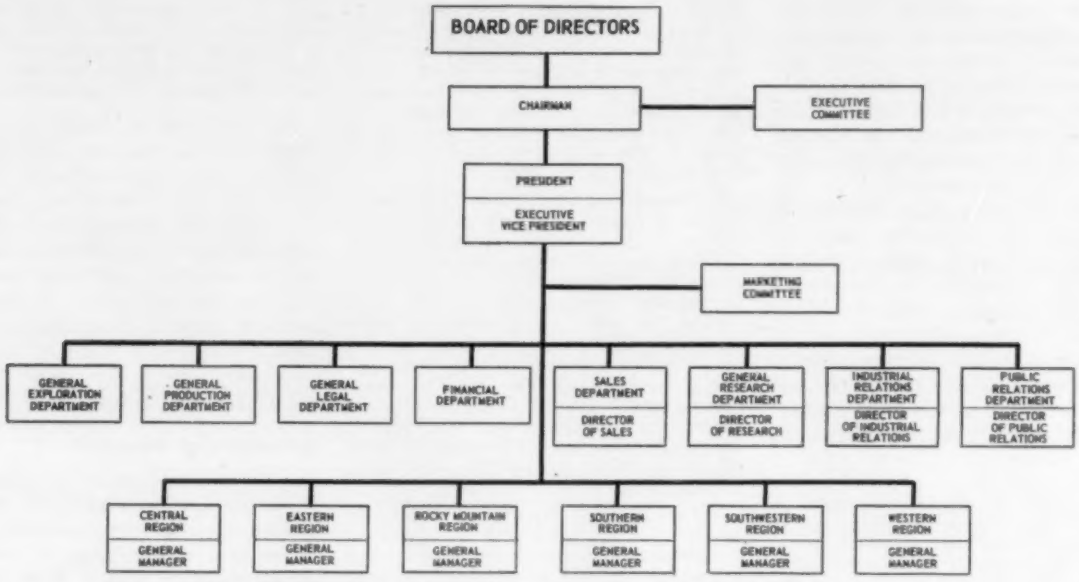


Fig. 3. Example of regional organization; large oil and petrochemical company.

Along the same line lengthy conversations have been held on the question of which is more important—good organization or good personnel. A company can often get along rather well for a time with a deficiency in either area. Small companies do surprising things under a brilliant leader and with practically no organizational pattern. There are larger companies which are well organized but have only mediocre personnel in the key spots. However, an observation of such companies over a term of years indicates that major, long-term success requires strength in both organization and personnel.

In these less well-defined areas of organizational planning the use of committees is another matter for consideration.

2. Use of Committees

Committees often have been criticized as symptomatic of poor organization. It is true that a committee should not be assigned an administrative, supervisory or executive role; it cannot supplant an executive position. However, a committee can properly fulfill the functions of adjudicating issues or making decisions where problems can best be resolved by those who represent several functions of the business and, therefore, several points of view. In short, committees should be brought into being only as a part of the organizational plan when there is a need to obtain the coordinated best judgment of a certain group.

3. Direct Access of Subordinates to All Executives

One of the criticisms often directed at a clear-cut organizational arrangement is based on the belief that the following of channels of organization puts everyone in a strait jacket; that it makes it impossible for people "down the line" to have personal contact with top executives and similarly prevents top executives from intimate knowledge gained through conversations at lower levels. Naturally, good organization should not preclude this type of contact. In any organization, the principle of direct access of one member of the organization to any other member of the organization is essential to healthy personnel relations and to the management of the enterprise. There should be free interchange of ideas and information throughout the organization, and individuals should deal with one another regardless of echelon or function. The only protective rule should be that instructions and orders should strictly follow organizational channels.

Conclusion

The subject of organizational planning is interesting in itself; such planning has come to represent a full career for some individuals who serve as management consultants. However, more and more, knowledge and skills in this area are becoming important to individuals who have aspirations of holding down positions of major business responsibility.

Technical, scientific knowledge alone is not enough for those who would fill top executive posts today. For example, since World War II, in the chemical, electrical, and other industries, there have been numerous top management positions filled by men from the outside whose primary qualifications were broad organizational and management know-how and whose technical knowledge in the given types of business was rather limited.

Clearly, the ideal qualification for top executive positions in the chemical industry is a combination of both technical and organizational skills. Furthermore, with the constantly advancing complexity of business and industry—not to mention government—the opportunities available for individuals with such balanced qualifications are going to grow tremendously in the years to come.

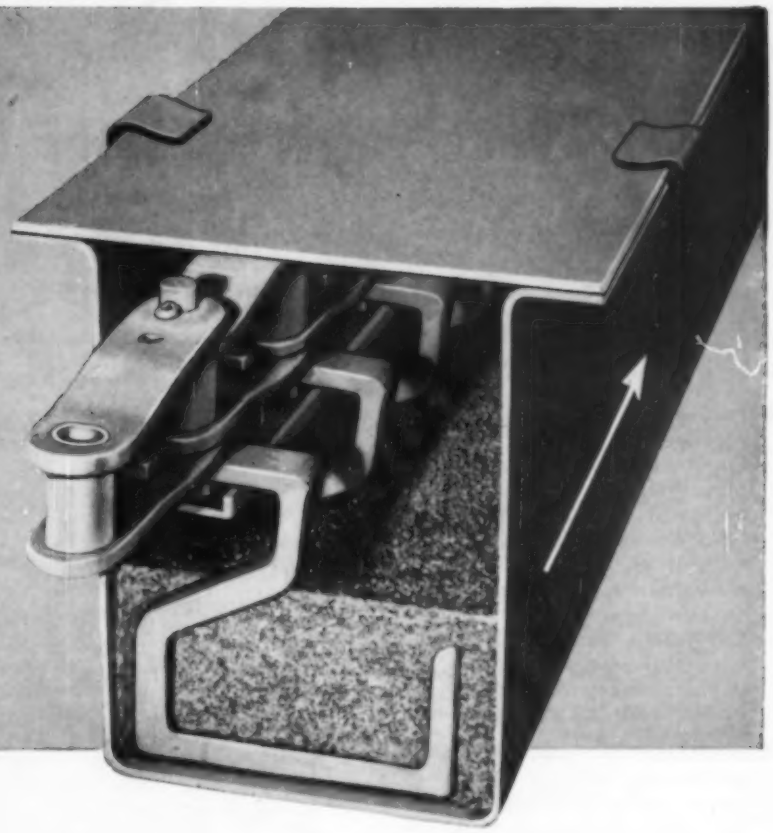
Literature Cited

1. Urwick, L. F., "The Elements of Administration," Harper & Bros., New York (1944).

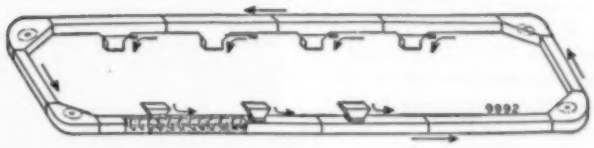
Presented at A.I.Ch.E. 47th Annual meeting, New York.

CONVEYS ANYTHING Economically from COAL to CORNSTARCH

with simultaneous pick-up or discharge at one or many points . . . without dust or contamination . . . in small space



This is an S-A REDLER Horizontal Closed Circuit Conveyor — and a very remarkable unit it is!



It conveys in four directions — can pick up and discharge at many points on its run simultaneously or selectively—does the work of several conveyors of other types. It is fully enclosed — dust-tight and contamination-proof. Because it moves materials *in mass,* in a solid column, it minimizes dust formation and degradation and practically eliminates explosion hazards.

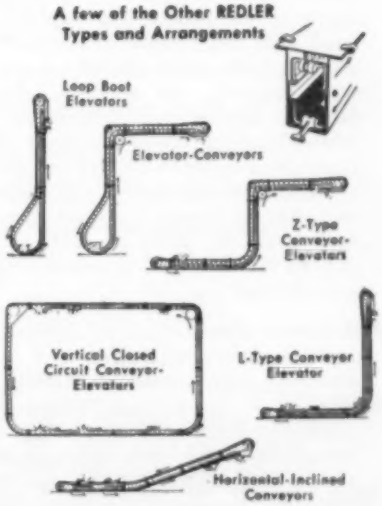
It is self-feeding and can be choke fed without jamming. Any excess material simply recirculates until needed. The REDLER is also self-cleaning, an important advantage when the operation calls for running various materials in sequence. It makes an ideal blending conveyor.

Unusually compact, REDLERS require a minimum of structural support. They can be easily and economically adapted to practically any plant layout.

The closed circuit REDLER is just one of many types furnished by S-A. If you handle or work with any kind of granular, pulverized, flaky or small lump material, a REDLER can help you do it better, cleaner and at lower cost.

Write for Catalog No. 140. We'll be glad to give you a preliminary cost estimate. No obligation, of course.

A few of the Other REDLER Types and Arrangements



SINCE 1907 S-A STEPHENS-ADAMSON MFG. CO.

STEPHENS-ADAMSON MFG. CO.

57 Ridgeway Avenue, Aurora, Illinois • Los Angeles, Calif. • Belleville, Ontario

Engineering Division
Specialists in the design and manufacture of all types of bulk materials conveying systems.

Standard Products Division
A complete line of conveyor accessories including centrifugal loaders—car pullers—bin level controls—etc.

Sealmaster Division
A complete line of industrial ball bearing units available in both standard and special housing

TITANIUM REFERENCE SHEET

(Part 1)

G. E. Hutchinson

assistant sales manager, Rem-Cru, Inc., Midland, Pa.

Definition: Titanium is a silver-grey, light-weight, metallic element. Commercially pure grade is 99% plus titanium. Impurities consist of small amounts of oxygen, nitrogen, carbon, and traces of metallic elements. Titanium's remarkable resistance to corrosion of seawater and of many inorganic and organic solutions makes it an important new structural material in the chemical, marine, and petroleum industries.

Composition: Two commercially pure grades are produced. Difference is based primarily on strength. Rem-Cru A-55 has a guaranteed minimum yield strength of 55,000 lb./sq.in., and A-70 has a minimum yield strength of 70,000 lb./sq.in. Both grades have the following specified chemistry: nitrogen: 0.10 max., carbon: 0.20 max.

Availability: Titanium is available in a wide variety of forms for prompt delivery as production facilities have kept the supply comfortably ahead of the demands of the aircraft industry. In addition, the Business Services and Defense Administration of the Department of Commerce order M-107 (1954), designed to encourage non-defense end uses for titanium, allows channeling up to 10% of mill output to civilian use, guaranteeing a continued supply.

Mill forms: Sheet—.012 to .187 in., surface finish equivalent to 2D stainless steel sheets. Standard size 36 in. by 96 in. Plate—over .187 in. to 6 in. Forging billets—round, square. Bars—round; hot rolled, rough turned or ground. Squares, hexagons or flats; hot rolled. Wire—1/15 in. to 1/2 in. round—coils or straight lengths. Tubing—welded. Also available as forgings, extruded shapes, extruded tubing, valves and fittings from manufacturers specializing in these forms.

Physical Properties: Density 0.1628 lb./cu.in. Melting point 3135° F. Thermal conductivity 105 B.t.u./(hr.)(sq.ft.)(° F./in.). Thermal expansion 5.0×10^{-6} in./in./° F.; 32 F. to 212° F. Specific heat 0.130 B.t.u./lb./° F. Specific heat tivity 370 ohms/cir.mil ft. Modulus of elasticity 15.5×10^{6} lb./sq.in.

Alloy Grades: Several high strength titanium alloys are produced, primarily for the aircraft industries. However, for certain high temperature applications, or where maximum strength-to-weight is needed, these will also be of interest to the chemical engineer.

Forming: Commercially pure titanium can be formed by brake forming, bending, hydro-press forming, spinning and deep drawing. Many operations can be done most conveniently at room temperature. Tighter bend radii, less required power, and reduced springback are gained by forming at 500-600° F.

Welding: Rem-Cru A-55 and A-70, commercially pure titanium, can be welded by various fusion welding techniques which serve to protect the weld metal from contamination of oxygen, nitrogen, and water vapor. Conventional techniques of inert arc welding are easily adapted to titanium. Spot welding and seam welding are widely used. Titanium welds show the same excellent corrosion resistance as titanium itself without special post-welding treatment. No successful technique has been found to date of welding titanium to steel.

Chemical Properties: The corrosion resistance of titanium will be discussed in detail in part 2 of the Titanium Reference Sheet. Titanium is outstanding in its resistance to seawater and marine atmosphere. It shows excellent resistance to a wide variety of chloride solutions which rapidly attack most engineering metals. Also, titanium is used in certain sulfuric and nitric acid applications. At elevated temperatures, titanium rapidly absorbs oxygen and nitrogen, eventually embrittling the base metals. For this reason, 1100 to 1200° F. is the maximum recommended operating temperature for present day commercial titanium alloys.

Mechanical Properties:

	Rem-Cru A-55	Rem-Cru A-70
Ultimate tensile strength, average,	75,000 lb./sq.in.	90,000 lb./sq.in.
minimum	65,000 "	80,000 "
Yield strength 0.2% offset, average	65,000 "	80,000 "
minimum	55,000 "	70,000 "
Elongation, average	25 %	20 %
minimum	20 %	15 %
Bend radius—sheet—105° V-block minimum (up to 0.070 in. thick)	2T	3T

No. 43

VERSATILITY

* DESIGN
* ENGINEERING
* FABRICATION

STAINLESS STEEL Evaporators, Sanitary Construction

STEEL Sulphur Burner

LEAD-LINED Reaction Vessels

ALUMINUM Distillation Units—Single, Central Bubble Cap Design

In the process industries, versatility applies to more than one phase of equipment production. At Acme, versatility includes working with all the ferrous and non-ferrous metals . . . with all types of equipment . . . and with virtually all processes.

For many applications, Acme has developed specialized types of equipment that offer unusual advantages in production efficiency and in operating economy, such as the Patented Sulphur Burner illustrated here. But whether a unit of specialized or of standard design is required, Acme versatility assures the maximum in performance.

ACME Processing Equipment

ACME COPPERSMITHING & MACHINE CO., ORELAND, PA.

DESIGN AND FABRICATION IN ALL FERROUS AND NON-FERROUS METALS.

BEAUMONT
ONE-DAY MEETING

H. A. Young (meeting vice-chairman), J. M. Nelson (chairman, Texas-Louisiana Gulf Section, A.C.S.), C. E. Huckaba (meeting chairman), W. V. Osgood (chairman, Sabine Area Section, A.I.Ch.E.) & F. M. Tiller (Dean of Engineering & head of Chem. Eng. Dept., Lamar State College).

72 Texas chemical plants have a valuation of $571.4 million, according to G. H. Turrentine of the Houston Chamber of Commerce, addressing the banquet session of the second annual one-day meeting sponsored jointly by the Sabine Area Section of A.I.Ch.E. and Texas-Louisiana Gulf Section of A.C.S. Approximately 300 attended. Sessions were held at Lamar State College of Technology, Beaumont. C. E. Huckaba was general chairman of the meeting. Mr. Turrentine continued with statistics that the petroleum refining industry employs 36,000, the chemical industry 31,000, and the total payroll is $160 million.

One of the important problems facing the *atomic power* industry, reported on by R. V. Andrews (Texas A. & M.), is the present requirement for large land areas near nuclear installations—all right for weapons materials processing plants, but not always convenient for strategically located power plants.

Boundaries of statistics exist in a practical sense more than some realize, said V. A. Kalichevsky (Magnolia Petroleum). When deviations are small, sampling procedures must become burdensome or lose their significance. When large and erratic, samples by statistical methods may be far from representative. Individual inspection in such cases is a safer practice. . . .

Only one *sulfite* paper mill is operating in the South, reported W. A. Mottio (East Texas Pulp & Paper). The rest are *sulfate* (Kraft) which turn out comparable quality paper.

Plastics took up an entire session. *Polyethylene* (F. P. Reding—Carbide & Carbon) is "tailored" by varying molecular weight and crystallinity, which is altered by branching. *PVC* (K. K. Fligor, Goodyear) has grown to 550 million lbs./yr. since 1931. *Fluorinated plastics* (W. M. Bruner, Du Pont) of F_4 class can be used up to 500° C., and F_3Cl types are limited to 390° C. *Alloy Rubbers* (R. C. Bascom, B. F. Goodrich) have as properties limits, the predominate limits of the rubbers and resins from which they are blended. *Reinforced Plastics* (P. L. McWhorter, Haveg) have been used for sulfuric acid tank unsupported roofs capable of holding a dozen men. *Cellulosics* (L. B.

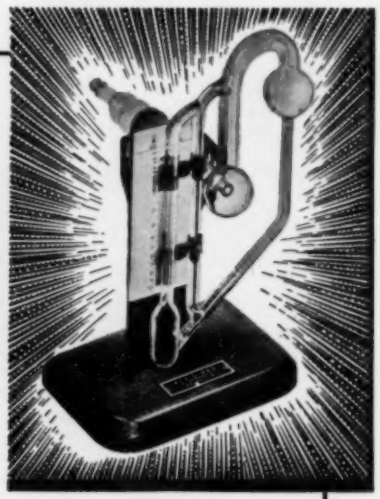
(*Continued on page* 68)

McLEOD GAUGES

are the most convenient and economical instruments for measuring low pressures of true gases from 1 micron up.

The uniform built in accuracy with ACE *Trubore tubing provides the finest in McLeod Gauges.

Permits interchangeable scales for quick accurate readings without recalibrating entire gauge.



8726

Top of capillary at square end is evenly flat. Adjustable scale enables lining up top of capillary, thus eliminating errors inherent in fixed automatic zeroing devices. Available in 4 ranges.

for Bulletin write DEP'T MG-G

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Specialists to Industry and Research

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Coffee break; Rawlings, Kindrick, Garland, Gibbs, & Wright.

Pressure Problems In Process Heat?

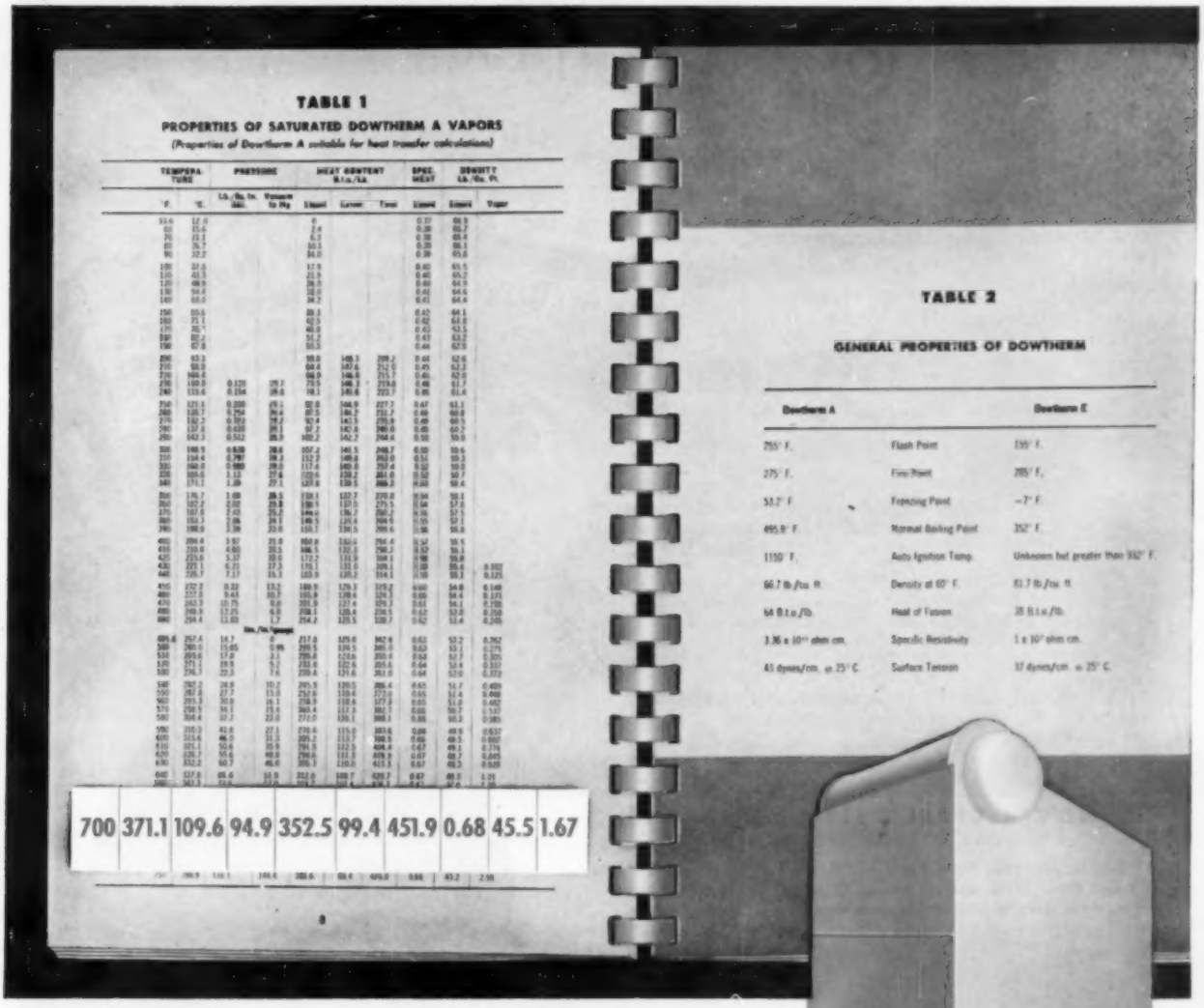

TABLE 1

PROPERTIES OF SATURATED DOWTHERM A VAPORS

(Properties of Dowtherm A suitable for heat transfer calculations)

TEMPERATURE °F	TEMPERATURE °C	PRESSURE Lb./Sq. In. Abs.	PRESSURE Vacuum In. Hg	HEAT CONTENT B.t.u./Lb. Liquid	HEAT CONTENT B.t.u./Lb. Latent	HEAT CONTENT B.t.u./Lb. Total	SPEC. HEAT Liquid	DENSITY Lb./Cu. Ft. Liquid	DENSITY Lb./Cu. Ft. Vapor
700	371.1	109.6	94.9	352.5	99.4	451.9	0.68	45.5	1.67

TABLE 2

GENERAL PROPERTIES OF DOWTHERM

Dowtherm A		Dowtherm E
255° F.	Flash Point	159° F.
275° F.	Fire Point	205° F.
53.2° F.	Freezing Point	−7° F.
495.8° F.	Normal Boiling Point	352° F.
1150° F.	Auto Ignition Temp.	Unknown but greater than 352° F.
66.7 lb./cu. ft.	Density at 60° F.	81.7 lb./cu. ft.
64 B.t.u./lb.	Heat of Fusion	35 B.t.u./lb.
3.36×10^{11} ohm cm.	Specific Resistivity	1×10^{11} ohm cm.
41 dynes/cm. @ 25° C.	Surface Tension	37 dynes/cm. @ 25° C.

DOWTHERM A

—pressure only 95 psig at 700°F.

Taking a page from the Dowtherm Handbook—high temperatures *do not* create high pressures when you use the modern heat transfer medium, Dowtherm®. The savings are obvious in less expensive, thinner walled equipment that occupies far less space.

When Dowtherm is used, heat can be controlled with *fraction-of-a-degree accuracy* by simple pressure regulation. Dowtherm provides low-pressure, high-temperature heat, extending the advantages of vapor-phase heating to much higher temperatures. The extraordinary thermal stability of Dowtherm makes it a natural for those applications demanding liquid-phase heating.

Your foresight in investigating Dowtherm may provide your company's competitive edge of the future. You'll find all the facts in the "*Dowtherm Handbook*", a valuable technical guide of process heat information. A request on your letterhead will bring it to you promptly. THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. DO 726A.

you can depend on DOW CHEMICALS

CONTINUOUS, CONTROLLED COOLING BY SANDVIK STEEL BELT COOLERS is part of this success story*

Processing News—

COMMERCIAL SOLVENTS PATENTED SHORT-CUT TO AMMONIUM NITRATE ELIMINATES EVAPORATION AND PRILLING——STERLINGTON, LA. PLANT DELIVERS 200 TONS PER DAY

Ammonia and nitric acid react directly at 400 degrees F. to yield molten nitrate, which is cooled to solid form on Sandvik belts, broken up at take-off and then crushed.

*Reprints of CHEMICAL WEEK article describing this installation and process, available from SANDVIK on request.

This installation spotlights one of the basic advantages of Sandvik's water-bed unit... *control of cooling rate.*

Sandvik's patented design "floats" the solid steel belt on a trough of water. The trough is sectionalized into separate tanks. Coolant in these tanks can be maintained at different temperature levels to suit the cooling rate required.

Some other processing advantages include:

- **Can be engineered to cool and convey, regulate thickness and temperature while cooling; obtain desired sizes in same operation; cool solids in sheet or granular form or crystallize liquids.**
- **Horizontal cooling surface permits depositing material in various thicknesses.**
- **Belts can be fitted with stationary or movable retaining side skirts.**
- **Solid, cold-rolled stainless or carbon steel belts provide a smooth, hard, impervious surface.**

Would a Sandvik unit improve your processing? Write, wire or phone.

SANDVIK STEEL BELT CONVEYORS
Division of Sandvik Steel, Inc.

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Branch Office: 230 N. Michigan Avenue, Chicago 1, Ill. FRanklin 2-5638

IN CANADA: SANDVIK CANADIAN LTD., 5675 Royalmount Ave., Montreal 16, P.Q.

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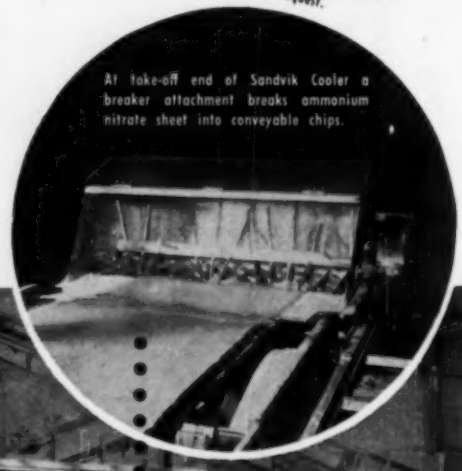
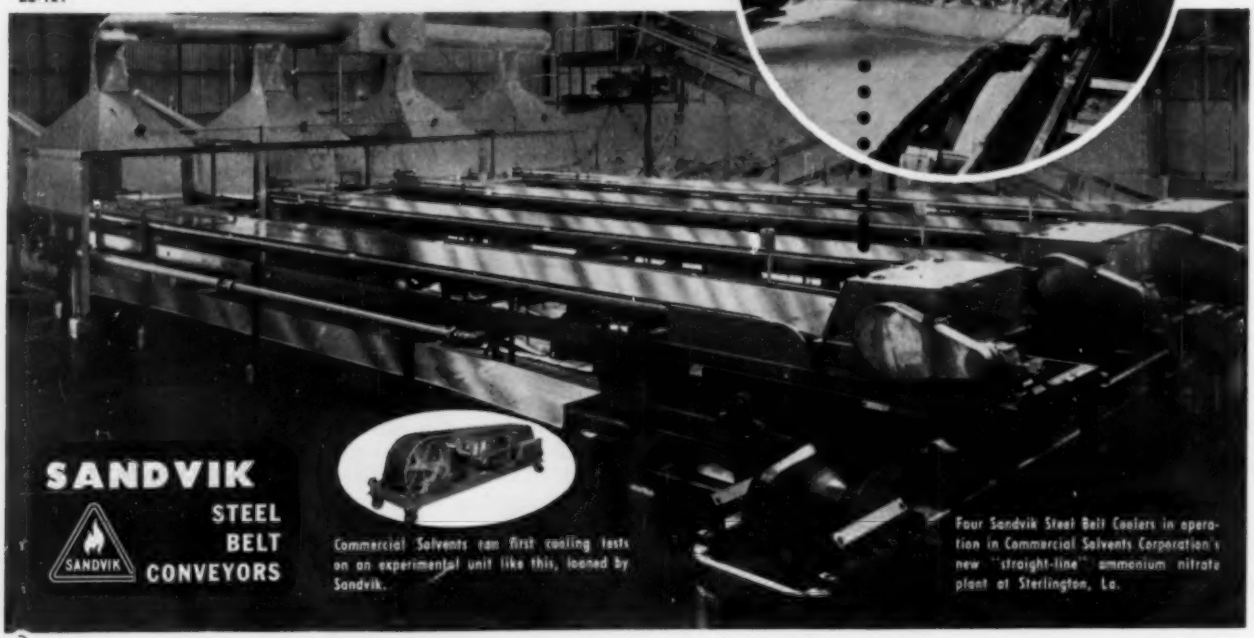


At take-off end of Sandvik Cooler a breaker attachment breaks ammonium nitrate sheet into conveyable chips.



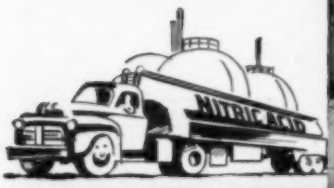
SANDVIK STEEL BELT CONVEYORS

Commercial Solvents ran first cooling tests on an experimental unit like this, loaned by Sandvik.

Four Sandvik Steel Belt Coolers in operation in Commercial Solvents Corporation's new "straight-line" ammonium nitrate plant at Sterlington, La.

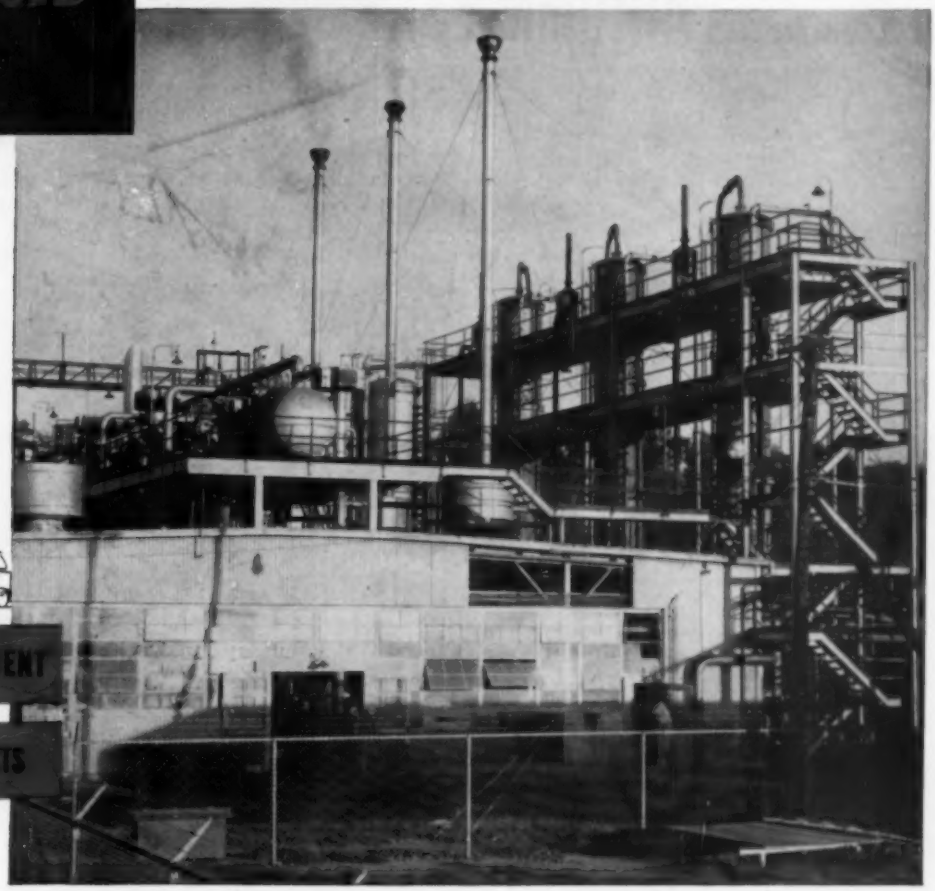
NITRIC ACID PLANTS

Girdler nitric acid plants employ the well-known Du Pont process, using high-pressure catalytic oxidation, to produce nitric acid. These plants offer greater economy, in both investment and operating costs, than atmospheric or low-pressure units. With the high-pressure process 55%-60% nitric acid is produced with efficient use of catalysts, and with lower utility requirements.



LOWER CAPITAL INVESTMENT

LOWER OPERATING COSTS



How you save money with GIRDLER know-how

WHEN you come to Girdler for nitric acid facilities, you get the benefit of the vast experience of DuPont as well as Girdler. DuPont's agreement with Girdler has combined the know-how of both companies. Moreover, Girdler has unsurpassed experience in building plants for the production of ammonium nitrate.

Because of this experience and new Girdler developments in nitric acid plants, you are assured substantial savings in capital investment and in operating costs when you specify Girdler. Mail coupon for bulletin on Girdler nitric acid plants.

MAIL COUPON TODAY FOR HNO_3 BULLETIN

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Louisville 1, Kentucky

Please send copy of new Bulletin on Girdler Nitric Acid Plants.

Company_____

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City_____ Zone____ State_____

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My Position_____

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GAS PROCESSES DIVISION: New York, San Francisco.
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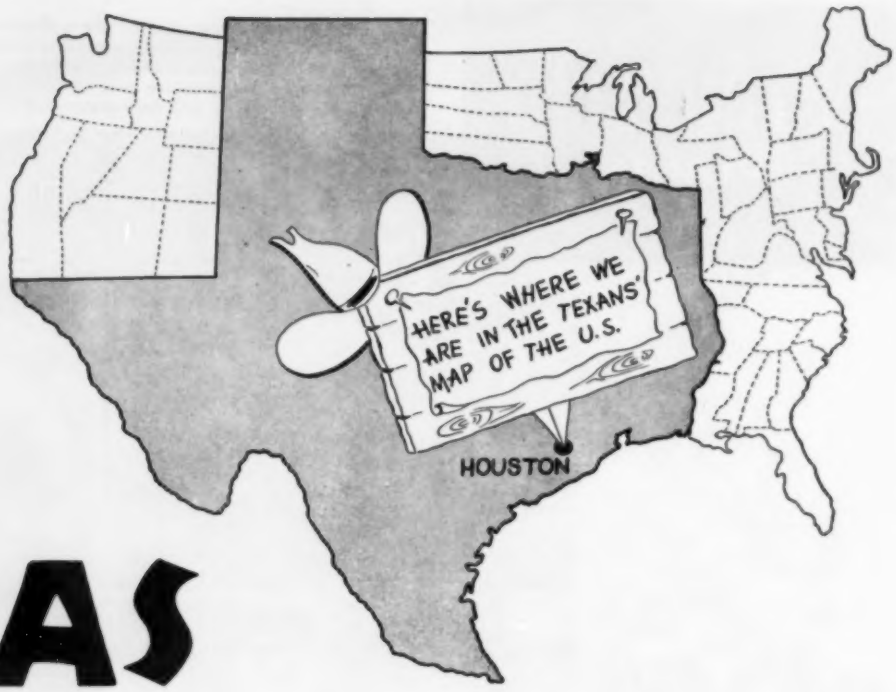


TEXAS

How 'bout ya'all hitchin' up the team to the Sunday buggy and headin' for Houston to the May "National Meetin' "? Now if you and the Missus can make this here ride you're gonna be the guests of some of the finest folks in the world and take part in one of the biggest national meetin's ever presented.

A. B. Wintringham

Ethyl Corp., Pasadena, Texas

You and the missus won't have any trouble in gettin' to Houston. Even if you don't have a buggy you'll find all trails headin' to Houston—even these paved ones or iron ones for cars and trains. They've even converted some good grazin' sections as a place for these flying machines to land. Now, if'n you figger there's gonna be too many people here, bein' a good Texan, we want to tell you that Texas is a BIG place and there's room for everybody. They tell us there'll be a fine technical program for all the hands as well as some mighty enjoyable doings for the ladyfolk. Gotta tell you too that on top of this program you and the Missus will have the opportunity of seeing what is called the "Golden Gulf Coast." We've got more industry, more potential, more resources, and more things to do than any other place in the country and Houston is smack in the middle of it. In fact, we're kinda hurtin' to tell you a little bit about some of the things that we're gonna get the chance of showin' to you.

You know, in Houston we've got the biggest city in the south—over a million folks. All the big names in the chemical world with hundreds of organic chemical products manufactured hereabouts. Why, we produce more gas and oil than any other state—35% of the nation's production—and we wouldn't even dare to tell you what we could do if shoved a little.

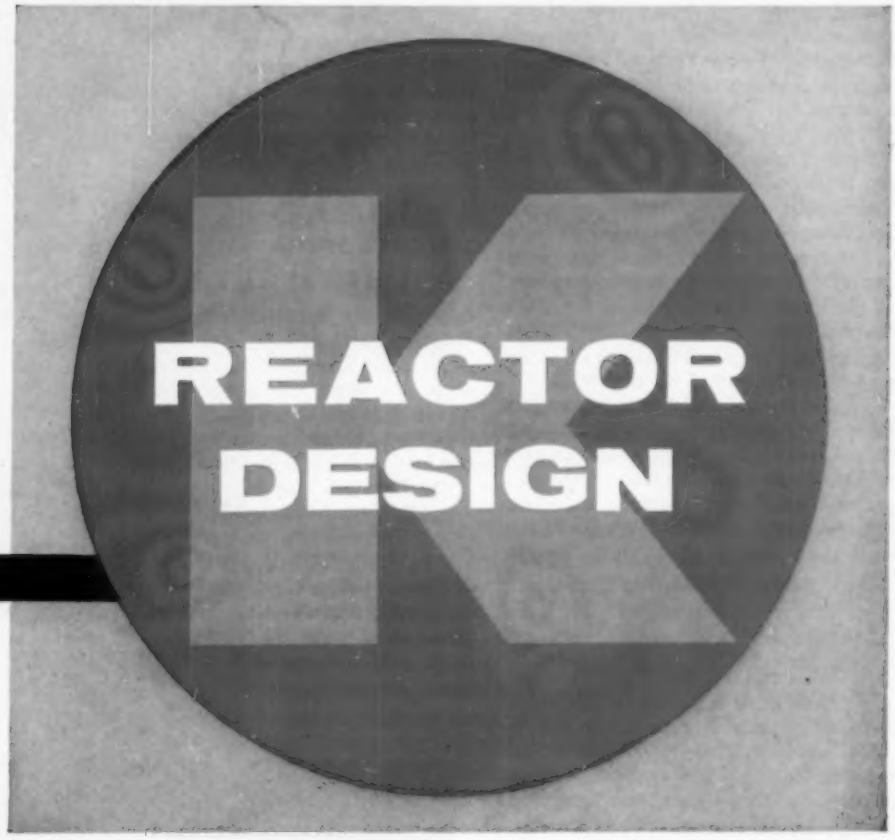
We'd be proud to show you some of the fine cattle grown in this country including Brahman, Charollaise, Hereford, Shorthorns, Santa Gertrudis, and Black Angus. Further, just 'cause we're kinda young don't think we don't have some of the big city treats. We've got the best symphony orchestra in all the South; all kinds of museums, three first-rate theater groups with the latest and best plays and our Coliseum and Music Hall for all types of shows from Broadway productions to world famous ballet troupes.

Chances are good that folks can make

(*Continued on page* 42)

Famed Harris County Sheriff's Mounted Posse.

FOR INCREASED AMMONIA DEMANDS



KEY TO HIGHER YIELDS—LOWER COSTS

IN THE PRODUCTION of ammonia, The M.W. Kellogg Company offers a number of processes for the generation and purification of synthesis gas—depending on the starting material and other local economic conditions. For the conversion phase, however, it is the Kellogg-developed, quench-type reactor which can contribute the most to increased plant capacity.

Assuring extremely accurate and flexible control of the temperature inside the catalyst mass, the Kellogg reactor eliminates the "hot spots" which cannot be averted with the conventional catalytic basket equipped with tubular heat exchangers. This in turn means, for any production rate, the gradient of temperature which gives the highest possible yields of ammonia per pass.

Capacities per day in excess of 300 tons per unit are now entirely practical with the Kellogg reactor. One such plant now being built by The M. W. Kellogg Company will have the unusually low investment cost of about fifty dollars per ton of annual capacity.

Your inquiries on ammonia or other proposed petrochemical projects are cordially invited.

PETROCHEMICAL PROCESSES AND PLANTS

CHEMICAL PROCESS DIVISION

THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK 7, N. Y.

The Canadian Kellogg Company, Limited, Toronto • Kellogg International Corporation, London

SUBSIDIARIES OF PULLMAN INCORPORATED

TEXAS

(*Continued from page* 40)

arrangements to show you some of our local scenes including the colleges and universities, Texas Medical Center, industries, and sports functions, and even a chance for you to enjoy swimming, golf and tennis while here.

Now if you're the homebody type we got more radio stations than you can count. Our three leadin' city newspapers have just pages and pages of radio and television news; there are three commercial television stations covering all the networks as well as the first educational television station in the U.S.A. You'll also have your choice of some mighty fine places to eat and relax.

To add to your good time you oughta take a trip down the famous Houston Ship Channel for 50 miles to the Gulf of Texas—ah mean Mexico—and you'll see why the Port of Houston is the 2nd largest port in the United States. (Actually, it's bound to be first but we Texans always respect old age.) You'll get a chance to see many of our local industries, the San Jacinto Battlegrounds and Monument and the Battleship Texas in the purtiest park and picnic grounds in the country. Down at the end of this 50-mile ditch dug by some other Texans you'll find Texas' answer to the Riviera and Miami Beach—Galveston—with the best of all resort doins'.

Why don't ya'all come—you and the missus tie up at one of our first rate hotels—the Shamrock—visit with us and see part of our "Golden Gulf Coast"? We've got a program and entertainment for you and the Missus that we think will make everyone of you say—"I'm agoin' agin'!!"

PROGRAM

Seriously, our program at this meeting is about the most ambitious we folks of the South Texas Section have ever put together. Scheduled are four technical symposia, two nontechnical symposia, a session on general papers, and a student session. The four technical symposia are:

- Nucleations
- Flow of Fluids through Porous Media
- Differences in Chemical Engineering Theory-Film Theory
- Azeotropic Distillation

The non-technical symposia are:

- The Professional Attitude (Sunday afternoon)
- The Chemical Engineering Curriculum

The technical programs commence Monday morning and extend through Wednesday afternoon.

During the four-day event arrangements have been made for inspection trips to twelve of the Gulf Coast chemical industries. These plant tours have been carefully selected because of their interest and uniqueness.

The ladies' program has been designed to give the wives the most complete picture of Houston and offer them enough varied interest to keep them entertained during the entire National meeting.

SO—CIETY NOTES

On Sunday evening from 6:00 to 8:00 p.m. the usual Institute's Git Acquainted party will be held in real luxury—in the Emerald Room of the Shamrock. As usual it's on the house, and Texas-style drinks will make your greetings to old acquaintances and your making of new friendships more pleasant.

On Monday, May 2, there will be no formally sponsored entertainment programs. There will be a theater party at the Alley Theater which is "in the round." The experiment in this type of presentation where the audience completely surrounds the stage, when first tried in Houston several years ago, met with immediate approval of the local audiences. All of Houston's newer theaters have been built in this pattern.

Blossoming with professional talent, the Alley Theater is a year 'round contribution to live entertainment in Houston.

This theater has a seating capacity of 200 seats, and is presenting "The Remarkable Mr. Pennypacker," a recent Broadway comic success starring Burgess Meredith.

On Tuesday evening you-all are invited to a typical "Western Party." Under the oaks at Arrowhead Race Track, you'll eat the best Texas barbecue (the best in Texas is better than anywhere else) served from real western chuck wagons. You will be delighted by the colorful show put on by the 21 (count them) horse drill team of the Harris County Sheriff's Mounted Posse. Some of you will get to ride fine quarter horses with real Texas Sheriffs.

To keep things in the right vein and tempo, Judge Roy Bean, legendary "Law West of the Pecos" will be on hand to mete swift justice to those who try to make a speech or be serious at all. He will have his jail for these offenders.

Plan to wear for this party western clothes—boots, bluejeans, cowboy shirts, and Stetson, if possible. If you have none of these, wear at least comfortable informal type of clothing. Come prepared to enjoy yourself.

AVERAGE TEMPERATURE FOR MAY 70-78° F.

Additional recreational facilities available will be swimming in the beautiful Shamrock pool and other pools in the nearby parks, tennis on the local courts, and golf for the enthusiast in many of the local parks and courses. Bring proper clothing and equipment for your desired recreation.

There will be an International Oil Exposition at the Coliseum in Houston, May 3 through May 8. Information and free tickets for this equipment show will be available at the information desk at the Shamrock.

Complete details April C.E.P.

Houston business district.

Struthers Wells FIRED HEATERS

FOR

PETROLEUM REFINING

GASOLINE PLANTS

CHEMICAL PLANTS

GENERAL INDUSTRIAL USE

Available in standard sizes from 500,000 to 40,000,000 BTU per hour

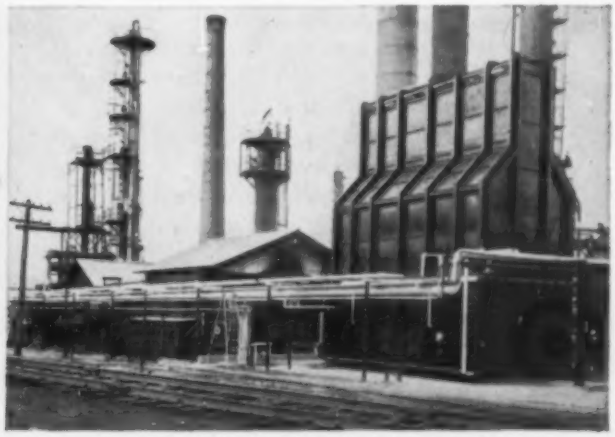
Hundreds of Struthers Wells fired heaters are now in service, in a wide range of sizes, for direct heating of petroleum oil, hydrocarbon gases, asphalt, air, oxygen, hydrogen and superheating steam, and for indirect heating using circulating heat transfer mediums. Circulating fluids used include molten metal, molten salt, Dowtherm, mineral oil, and a number of other organic materials.

In connection with heating systems, we can supply all equipment items, as a complete unit, including wired and piped panel control boards.

We also supply electrically heated units—and special heating and cooling equipment, including water heaters.

A Struthers Wells Type CV absorption oil heater installed at a gasoline plant of one of the largest gas transmission companies, the third installation for this company.

A fired heater for Struthers Wells Dowtherm heating system, one of two units installed in a new chemical plant for the production of vat dyes.



Shown above are two Struthers Wells heaters in petroleum refinery service. At right is a three-coil heater used in catalytic reforming of gasoline. At left is a heater which was installed over 23 years ago, and is still in continuous service.

STRUTHERS WELLS CORPORATION

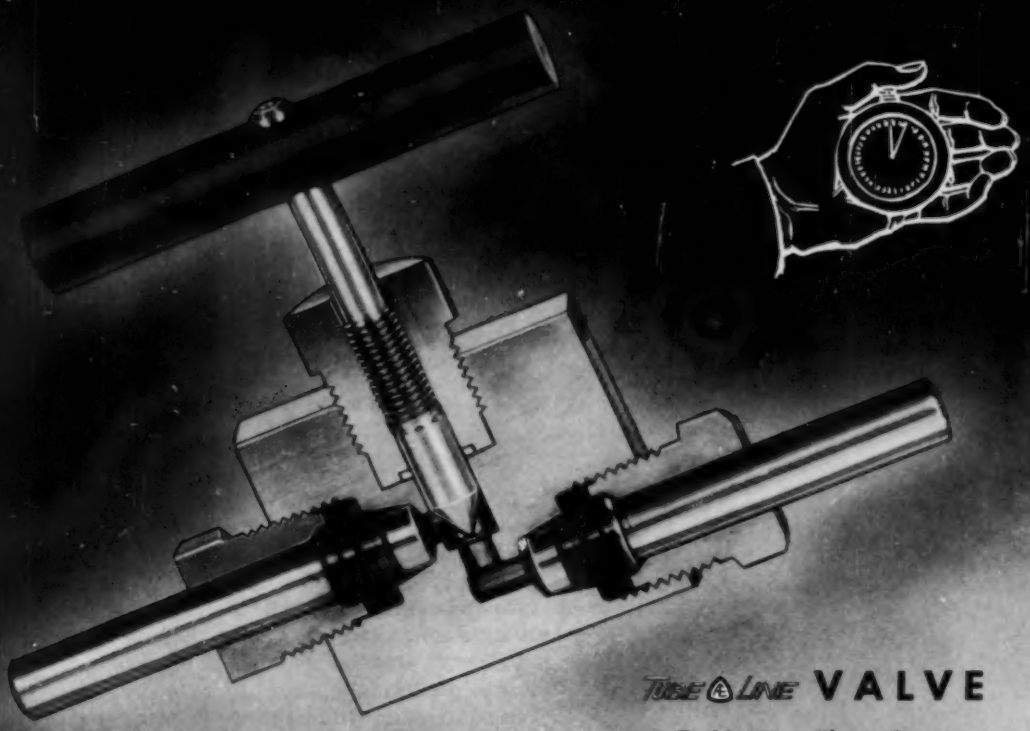
WARREN, PA.

PLANTS AT WARREN, PA. AND TITUSVILLE, PA.

Offices in Principal Cities

Struthers Wells

NEW... Low Cost Tubing Valve You Can Install in Seconds



TUBE-A-LINE VALVE

- No Pipe Threading
- No Beveling
- Gas Tight Seal
  Up To 4000 P.S.I.

Here is a high quality, low-cost valve for tubing . . . the NEW TUBE-A-LINE Valve. You can cut it into the lines in a jiffy . . . requires no threading, no beveling, no pipe-wrench . . . and every joint is a union. What's more, this new valve costs less initially and works better than any conventional screw-end valve.

Here's how the TUBE-A-LINE Valve works: Cut tubing to required length, slip adapter nut and sleeve on, insert into valve and tighten joint . . . a gas-tight seal up to 4000 p.s.i. in a matter of seconds.

The TUBE-A-LINE Tubing Valve body is made of 304 stainless steel, the stem is 410 stainless steel heat treated and ground, with rolled threads. Gland nut is 416 stainless steel, the stem thread is in the gland nut and outside the pressure zone.

Full details on TUBE-A-LINE Tubing Valves are available in Bulletin 255. Write for it.

TUBE-A-LINE

AUTOCLAVE ENGINEERS, INC.

860 EAST 19TH ST. • ERIE, PENNSYLVANIA

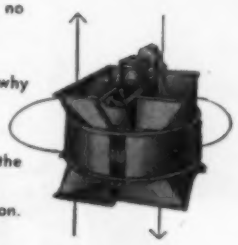
reduce slag

stay on stream at top capacity months longer with the Ljungstrom® Air Preheater

HOW FAST IS "WRITE OFF"?

By cutting turnaround time alone, the Ljungstrom means major savings for you. When you take the other Ljungstrom advantages into account—up to 20% fuel saving . . . more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . consistently higher through-put . . . higher product quality—you can see why a Ljungstrom is paid out in just a few months.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write The Air Preheater Corporation.



Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

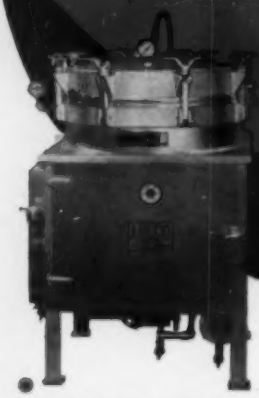
Slag—primary cause of reduced capacity—can be substantially reduced by the Ljungstrom Air Preheater.

That's because preheated air mixes more thoroughly with fuel. The result is better combustion . . . and less slag-forming material present in the furnace. Oil tubes stay cleaner . . . stills stay on stream at top capacity for months longer. As an example, one pipe still in an eastern refinery dropped from 16,000 barrels a day to 12,000 because of slag. Now, with a Ljungstrom and modern high-temperature burners, the still operates continuously at 18,000/20,000 barrels.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

HILCO

provides *lower* vacuum pump maintenance costs . . . *increased vacuum*—



OIL RECLAIMER

HILCO OIL RECLAIMER

purifies vacuum pump oil by continuous recirculation, either on a full-flow or by-pass basis, or intermittently on a batch basis, depending upon the requirements and physical layout of your plant.

HILCO OIL RECLAIMER SYSTEMS are the finest available for VACUUM PUMP users

A simple, economical and efficient method of restoring contaminated lubricating and sealing oil to the full value of new oil. HILCO Oil Reclaimers are used for the purification of vacuum pump oil in conjunction with the manufacture of transformers, condensers, capacitors, drugs, vitamin concentrates, radio tubes and light bulbs, essential oils, optical lenses, refrigeration compressors, titanium and many other products. A HILCO will produce and maintain oil free of all solids, sludge, acid, moisture, solvents, and dissolved gasses and restore viscosity, dielectric strength and other specifications to new oil value.

THERE IS A HILCO FOR EVERY OIL PURIFICATION JOB . . . AND EACH OFFERS YOU

These Features!

- Continuous, all electric, automatic operation.
- Low operating temperature.
- Vacuum processing.
- Infrequent operation—low operating costs.

WRITE TODAY! *For Complete Details Ask For Bulletin R-160*

THE HILLIARD *Corporation*

144 WEST FOURTH ST. ELMIRA, N. Y.

IN CANADA: Upton-Bradeen-James Ltd., 890 Yonge St., Toronto; 3464 Park Ave., Montreal

nuclear *division* engineering

APRIL NUCLEAR CONFERENCE PROGRAM

A three-day conference on nuclear engineering, sponsored by the University of California, the A.I.Ch.E. Nuclear Engineering Division, the Southern and Northern California Sections of A.I.Ch.E., and three other groups, will be held April 27 through the 29th. The meeting will take place at the University of California campus in Los Angeles.

The program is to include panel discussions on "water and liquid metals as primary working fluids; radiation sources for industrial applications; and power reactor control during load changes."

Papers will be given on: "Boiling water reactors; radiation sources for industrial applications; dynamic behavior of reactors and reactor systems; nuclear power systems; and radiation effects on materials."

Registration fee is $10 which includes one dinner. Further information including list of accommodations can be had from Dept. of Conferences and Special Activities, University Extension, U. of California, L.A. 24, Calif.

AEC RELEASES PATENTS

The AEC will grant non-exclusive, royalty-free licenses on 21 patents, as part of its program to make non-secret technological information available for use by industry.

Applicants for licenses should apply to the Chief, Patent Branch, Office of the General Counsel, U. S. Atomic Energy Commission, Washington 25, D. C., identifying the subject matter by patent number and title. Copies of these patents may be obtained from the U. S. Patent Office.

Patent No.: 2,695,213 Recovery of Zirconium Tetrachloride from its Complex Compounds; 2,695,214 Method of Making Metallic Oxyfluorides; 2,695,268 Process for the Concentration of Isotopes; 2,695,715 Remote-Control Manipulator; 2,697,518 Flotation Methods for Uranium Ores.

ATOMIC MICROCARDS

A complete file of AEC unclassified reports, from their beginning, are now available in Microcard form. It is planned also to have copies made of new technical reports issued in microcard form a few weeks after they appear.

For further information, write: Microcard Foundation, Godfrey Memorial Library, Middletown, Conn.

stainless steels are thoroughbred, too

The experienced exhibitor rents extra stalls... leaves them empty... to prevent contamination of his thoroughbred pets by canine neighbors.

To develop their best qualities demands *exclusive* care. That is why Sun Ship's new Alloy Products Shop has been planned for the *exclusive* fabrication of stainless and alloy steel products. When you have selected from the many available Alloys a stainless steel best suited for your service condition, you have done only half the job. You must also provide for the best possible fabrication if you are to have full protection—"A Thoroughbred Job."

Why entrust stainless steel to be fabricated in the same shop where carbon steel products are fabricated, and subject this precious metal to contamination with iron fragments, dust, or other harmful elements? A segregated shop is your answer.

Sun Ship now operates an all-alloy shop, one especially built and equipped for fabricating stainless and alloy products as they should be—segregated from carbon steel fabrication.

We emphasize the fabrication of medium and heavy stainless, alloy and aluminum products for industry.

Try Sun Ship for stainless fabrication as it should be done.

Our Sales Engineering Department will be pleased to assist you with any of your fabrication problems.

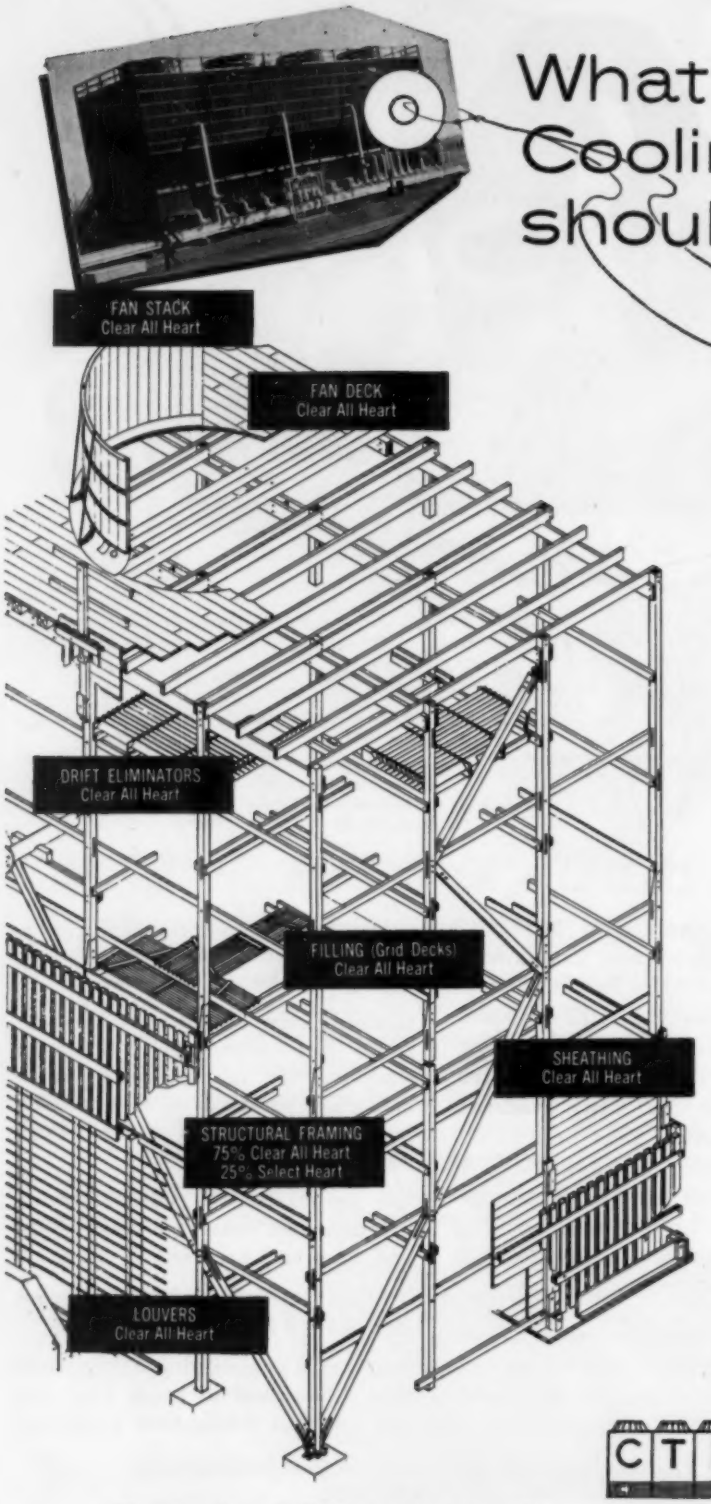
Sun Ship also makes all types of carbon steel pressure vessels.

ALLOY PRODUCTS SHOP

OF Sun SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • CHESTER, PA. • 25 BROADWAY, NEW YORK CITY

What every Cooling Tower buyer should know



■ A cooling tower is an important piece of industrial equipment. It can be a constant source of trouble, or a sound, profitable investment. Look at the specifications when buying a cooling tower, not at the price tag. The quality of materials from which a tower is fabricated, the structural design, the performance of mechanical equipment, its life expectancy, the experience and integrity of the manufacturer—these are the real values of a cooling tower. Be sure that the tower *size* and the *quality* of the materials meet your carefully prepared specifications.

The cost of a cooling tower is divided approximately 70% for the tower itself and 30% for mechanical equipment. Big price differences lie in the quality and sizes of lumber used in their construction. Fluor towers are prefabricated from California redwood. "Yard Grades" of California redwood are selected in this order: (1) Clear All Heart, (2) A Grade, (3) Select Heart, (4) Utility, (5) Construction Heart, (6) Sap Common, (7) No. 3 Common. Fluor uses only Clear All Heart and Select Heart in their cooling towers. A Grade contains sapwood and Fluor does not use lumber containing sapwood. The only Select Heart in a Fluor tower is about 25% in structural lumber. All the rest is Clear All Heart—the best there is.

Hundreds of thousands of board feet go into a cooling tower and prices will vary as much as $17 per thousand board feet between one grade and the next. You can readily see how substituting a lesser grade will substantially lower the price of a tower, and lower its operating life. When you buy on price, you do *not* get what you pay for.

CTI

Fluor has been building cooling towers for 34 years and has repaired many hundreds of them —all makes and models. We know from long experience what should go into a cooling tower and what should not. Fluor towers are universally recognized as the finest you can buy. We cannot compromise with quality or offer an inferior tower to satisfy a price. We urge you to be guided by your carefully prepared specifications and not let the cost of a tower be the sole influence.

BE SURE WITH

FLUOR

THE FLUOR CORPORATION, LTD
LOS ANGELES 22, CALIFORNIA
FLUOR OF CANADA · TORONTO
FLUOR PERUANA, S.A. · LIMA
HEAD WRIGHTSON · LONDON

ENGINEERS
CONSTRUCTORS
MANUFACTURERS

NEW YORK
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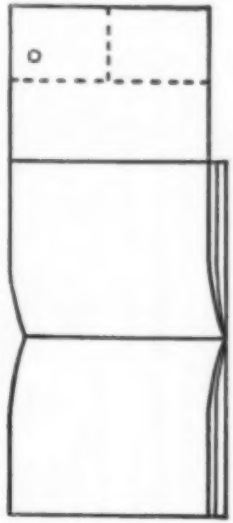
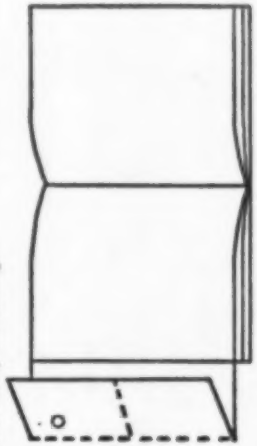
for your information

This C.E.P. information service is a convenient way to get the chemical engineering information you need on the new equipment, an advertised products, on the newly announced developments reported on these pages. A one post card inquiry designed to bring data quickly and easily. Circle the items of interest, sign your name, position, address, etc., and drop in the mail.

Just a moment is needed to learn how to use this insert. When looking through the front part of the magazine pull the folded portion of the insert out to the right, and the numbers on the post card are convenient for marking. THEN . . . .



as you pass the pull-out page, and it is on the left, fold the post card back along the vertical scoring, and once again the numbers are handy for circling.



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25 West 45th Street
New York 36,
New York

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CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

Please do not use this card after June, 1955

PRODUCTS

IFC Diethylene Glycol. For humectant action plus solvent action, low viscosity, freezing point, & cost. Available in commercial quantities. Carbide & Carbon Chemicals Co.

3R Rotary Sifter. Bar-Nun all-metal rotary sifter is a compact, self-contained, & motor-driven unit. Makes particle-size separations on most substances. B. F. Gump Co.

4A Valves. Clamp gate valve of rugged design & close tolerance machining. Many types all-iron or brass-trimmed. Crane Co.

5A Unibestos. A material for exacting insulation needs. Will not crack, crumble or powder. For temperatures to 1,200°. Union Asbestos and Rubber Co.

6L Mechanical Seal. Drop-tight service over long periods where this Teflon pressure-balanced bellows design seal is employed. Sizes ⅞ to 2⅛ in. United States Gasket Co.

7A Processing Equipment. Nooter workscope covers fabrication through erection of custom fabricated storage tanks & processing equipment. Nooter Corp.

8A Haveg Parts. Pipe, valves, & fittings of Haveg for use where liquids are hot & corrosive. Light weight. Good resistance to thermal shock. Haveg Corp.

9A Preferred Assignments. You may now choose your job & your location if you work in the field of electronics. Motorola Communications & Electronics Division

10A Celite Powders. A powdered material which absorbs twice its own weight of liquid. Helps control viscosity in adhesives. Johns-Manville.

11A Karbate. Process equipment made from Karbate impervious graphite meets severe requirements. Results in savings in service conditions. National Carbon Co. Div. of Union Carbide and Carbon Corp.

12L Line Blind Valves. Absolute line shutoff by one man in one minute using Hamer visible shutoff line blind valves. Reduces damage to equipment & removes sparking hazard. Valves, Inc.

13A GLC Anodes. Precise performance of these anodes in electrolytic cell operations reliably controls production costs. Great Lakes Carbon Corp.

14L Mixer. Unique shaped mixer bowl presents greater ratio of heated surface to mix. Overlapping sigma arm exposes new surfaces. Read Standard Corp.

15A Vanton XB Pump. Unit equipped with corrosion resistant flex-i-liner this self priming rotary pump available in new design. Vanton Pump & Equipment Corp.

16A Dryers. Precision-built, pre-fabricated dryers featuring many improvements. Have continuous hopper feeds, & automatic leveler to conveyor belt. National Drying Machinery Co.

17A Tygon ATD Paint. A hot spray paint which builds film thickness of 3 mils or more at a single pass—5 mils or more in two coats. U. S. Stoneware Co.

18L Distillation Apparatus. Trays of every type for use in distillation plus other processing equipment either standard or custom-built. Badger Mfg. Co.

19R Fittings. Ball bearing swivel fittings offer less friction, turn easily, wear longer give free & easy rotation under extreme pressures. Emsco Mfg. Co.

20A Concentrator. New high capacity, heavy duty concentrator assures extra power & rugged sanitary construction for tough jobs. 40 h.p. input. The Sharples Corp.

21A Pulverizers. For use in the chemical, drug, cosmetic, & allied industries. Mikro-D pulverizers guarantee better products in greater volume. Pulverizing Machinery Div. of Metals Disintegrating Co., Inc.

22L Pumps. Where wide range of gallonages & heads are required installation of one cradle results in wide choice of pump-ends & drives. Ingersoll-Rand Co.

23A Transverse Lubrication. Lubriflush a complete relubrication system without disassembly of motor. Saves down time & costs. U. S. Electrical Motors, Inc.

25A Fertilizer. Crystalline ammonium nitrate fertilizer in a single step by use of Stengel process now available on license. Chemical and Industrial Corp.

27A Ko-Kneaders. Continuous-mixing Ko-Kneaders provide possibility of switch from batch to continuous processes in mixing, blending, & kneading operations. Baker Perkins Inc.

28A Ductile Cast Iron. Because material has a spheroidal graphic microstructure mechanical properties are closer to those of steel than gray iron. Provides logical material for process equipment. The International Nickel Co., Inc.

29A Electronics. Now you may choose your preferred assignment in your preferred location in the field of military & allied industrial projects. Motorola Communications & Electronics, Inc.

30A Filters. Of standard drum continuous vacuum fiber design filter incorporates items such as rubber grids of thermoplastic type, easy access, bronze valve & wear plates, etc. Eimco Corp.

32A Centrifugal Pump. Determination of efficient speeds can reduce costs & increase production. Unit has all-speed hydraulic drive in speeds from 0 to maximum rev./min. Tolhurst Centrifugals, Div. American Machine and Metals, Inc.

33A Conveyor. A horizontal closed circuit conveyor which conveys anything from coal to cornstarch & conveys in four directions. Stephens-Adamson Mfg. Co.

35A Processing Equipment. Working with ferrous & non-ferrous metals, with all types of equipment & processes has developed specialized types of equipment with special advantages. Acme Coppersmithing & Machine Co.

36BL McLeod Gauges. Convenient & economical for measuring low pressures of true gases from 1 micron up. Uniform built-in accuracy with Trubore tubing. Ace Glass Inc.

37A Dowtherm A. Heat control within fraction of degree accuracy by simple pressure regulation. Unit gives low-pressure-high-temperature heat. Extends advantage of vapor-phase to high temperatures. Dow Chemical Co.

38A Coolers. Continuous, controlled cooling results from use of Sandvik steel belt coolers. Patented design floats solid steel belt on trough of water. Sandvik Steel, Inc.

39A Nitric Acid Plants. A combination of DuPont & Girdler results in employment of know-how of both companies, & reduction of capital investments & operating costs. Girdler Co., Gas Processes Div.

41A Reactor Design. Several processes available for generation & purification of synthesis gas in ammonia production, but quench-type reactor contributes most to plant capacity. Designed by M. W. Kellogg Co.

PRODUCTS (Continued)

76BL Laboratory Ware. Transparent & non-transparent lab-

Chemical Engineering Progress

Numbers followed by letters indicate advertisements, the number corresponding to the page carrying the ad. This is for ease in making an inquiry as you read the advertisements. Letters indicate position—L, left; R, right; T, top; B, bottom; A indicates a full page; IFC, IBC, and OBC are cover advertisements.

Be sure to give name, address, position, etc.

Remember, the numbers on the upper portion of the card bring you data on only the bulletins, equipment, services, and chemicals reported in these information insert pages. The lower portion of the card is for the advertised products, and is keyed not only to advertising pages, but also to the memory-tickling list under the heading Products.

43A Heaters. Heaters for the petroleum & chemical industries, also for general industrial use in sizes 500,000 to 40,000,000 Btu/hr. Struthers Wells Corp.

44A Tubing Valves. Installation in seconds. Requires no threading, beveling, or pipe-wrench. Every joint a union. For pressures to 4,000 lb./sq.in. Autoclave Engineers, Inc.

45A Air Preheater. Use of Ljungstrom unit permits reduction of slag & staying on stream at top capacity months longer than usual. Air Preheater Corp.

46L Oil Reclaimer. A simple, efficient, & economical method for restoration of contaminated lubricating & sealing oil to value of new oil. Hilliard Corp.

47A Alloy Products. Fabrication of alloy & stainless steel products is sole function of new alloy products shop. Sun Shipbuilding & Dry Dock Co.

48A Cooling Towers. Fabricated from California redwood these towers said to guarantee long life & performance. Built to your specifications. Fluor Corp., Ltd.

53A Spray Dryer. New compact, high yield, easily cleaned, semi-works spray dryer. Fully prefabricated. Requires only few hours to erect. Bowen Engineering, Inc.

55A Dryers & Calciners. Determination of all aspects of heat process project available in experimental & development laboratory. C. O. Bartlett-Snow

57A Chempump. Handling problem fluids without failure or leakage of any kind is feature of Chempump. Combines pump & motor in single hermetic unit. Chempump Corp.

(Continued on back of this insert)

Please do not use this card after June, 1955

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115	116	117	118	119	120	121	122	123	124	125	126	127	128

Advertisers' Products

IFC	3R	4A	5A	6L	7A	8A	9A	10A
11A	12L	13A	14L	15A	16A	17A	18L	19R
20A	21A	22L	23A	25A	27A	28A	29A	30A
32A	33A	35A	36BL	37A	38A	39A	41A	43A
44A	45A	46L	47A	48A	53A	55A	57A	59A
61A	63R	65R	66BL	67R	68L	69R	70L	71R
72L	73R	74TL	74BL	74BR	75R	76TL	76BL	77R
78L	79R	80L	81R	82TL	82BL	83R	85R	86L
87R	89TL	89BL	89BR	90L	90TR	90BR	91TR	91BR
94TL	94BL	94BR	95BR	106A	IBC	OBC		

Chemical Engineering Progress Data Service

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Position .....

Company .....

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City .....Zone.....State .....

☐ I want a subscription. Bill me $6.00 for a year.

March, 1955

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100	101	102	103	104	105	106	107	108	109	110	111	112	114
115	116	117	118	119	120	121	122	123	124	125	126	127	128

Advertisers' Products

IFC	3R	4A	5A	6L	7A	8A	9A	10A
11A	12L	13A	14L	15A	16A	17A	18L	19R
20A	21A	22L	23A	25A	27A	28A	29A	30A
32A	33A	35A	36BL	37A	38A	39A	41A	43A
44A	45A	46L	47A	48A	53A	55A	57A	59A
61A	63R	65R	66BL	67R	68L	69R	70L	71R
72L	73R	74TL	74BL	74BR	75R	76TL	76BL	77R
78L	79R	80L	81R	82TL	82BL	83R	85R	86L
87R	89TL	89BL	89BR	90L	90TR	90BR	91TR	91BR
94TL	94BL	94BR	95BR	106A	IBC	OBC		

Chemical Engineering Progress Data Service

Name .....

Position .....

Company .....

Address .....

City .....Zone.....State .....

☐ I want a subscription. Bill me $6.00 for a year.

March, 1955

PRODUCTS (*Continued*)

59A Storage Tanks. Utilitanks, glassed both sides, will not rust or require painting. Cleaned by simple hosing. New dryer-blender permits drying of corrosive products in 1/5 usual time. Pfaudler Co.

61A Methyl Mercaptan. Available in any desired quantity up to tank cars now made possible by modern plant. Pan American Chemicals Div., Pan American Refining Corp.

63R High Alloy Castings. Castings to your specifications for high temperature, highly corrosive service. Static castings of 7 ton or more; single centrifugal castings to 4½ ton. Duraloy Co.

65R Pumps. The All-Chem pump made of Teflon & stainless steel handles 70% of corrosive chemical needs in laboratory, pilot plant & small volume pumping in production. Eco Engineering Co.

66BL Maintenance Service. Available at any hour of day or night & every day in the year this service for repair or maintenance of any tubular equipment. Condenser Service & Engineering Co., Inc.

67R Portable Lab Dryer. A mobile unit, flexible & versatile for steam or electrical heating of air stream. Fully instrumented. C. G. Sargent's Sons Corp.

68L Pumps. Air actuated metering & proportioning pumps for use where conventional pumps are unsatisfactory. Have an air cylinder drive. Fast, accurate start & immediate stop. Hills-McCanna Co.

69R Dryers. Manufacturer with know-how to help in solution of materials handling problems arising in feeding dryer & delivery of product to subsequent processing equipment. Proctor & Schwartz, Inc.

70L Pumps. Vertical jacketed pumps designed for pumping sulphur, phthalic anhydride, resins, etc. Heat medium may be steam, dowtherm, etc. Lawrence Pumps, Inc.

71R Tube Mills. For wet or dry grinding tube mills designed to meet specific needs, 2 to 10 ft. diam.; 6 to 35 ft. long; single or multiple compartments. Hardinge Co., Inc.

72L Pressure Switch. Improved Maletron pressure switch for use in explosive atmospheres. Affords extreme accuracy, operates in any position, is easily adjustable. Barksdale Valves.

73R Filter Presses. Units may be used for many operations other than cake recovery or clarification by variation in design. T. Shriver & Co., Inc.

74TL Laboratory Ovens. For baking & drying operations at 650° to 1,000° maximum temperatures. Combination temperature scales. Grieve-Hendry Co., Inc.

74BL Coil Assemblies. Made of lead, copper, aluminum, stainless or carbon steel are various types of heating equipment. Recommendations available on design & material. Rempe Co.

74BR Spray Nozzles. A reference manual complete in every detail, gives reference data on thousands of standard & special spray nozzles. Spraying Systems Co.

75R Demisters. Tailor-made demisters for quick installation in new or existing equipment. Separation efficiency 99.9%. Otto H. York Co., Inc.

76TL Filtration. A 44-page book of facts on filtration for easy reading. Classified for instant reference. D. R. Sperry & Co.

76BL Laboratory Ware. Transparent & non-transparent laboratory ware fabricated from Vitreosil (vitreous silica) for exacting requirements. Thermal American Fused Quartz Co., Inc.

77R Force Feed Lubricators. Models available for operation against discharge pressures to 30,000 lb./sq.in. gage insure maximum life of oil seals. Manzel Div. of Frontier Industries, Inc.

78L Cone Blender. Fast thorough mixing of chemicals, dyestuffs, pharmaceuticals, other products. No separation of materials. Low power requirements. Paul O. Abbé, Inc.

79R Filters. Rubber-lined filters save expense of acidizing brine disposal wells or drilling new ones. Save money in waste disposal. R. P. Adams Co., Inc.

80L Filters. Pilot plant filters aid in reduction of development costs. If your problem is continuous filtration communicate with Filtration Engineers, Inc.

81R Tube Cleaners. Rotojet tube cleaners for use in tubes & pipes from ½ to 12 in. i.d. Wide variety available meet most requirements. Elliott Co., Roto Div.

82TL Laminates. Use of glass reinforced polyester, epoxy, & phenolic laminates suggested for major corrosion resistance. Carl N. Beetle Plastics Corp.

82BL Vaporizers. For use with ammonia, propane, & chlorine, reboiler type, capacities to 10,000 gal./hr. Eliminate surging & steam hammer. Richard M. Armstrong Co.

83R Quikupl. Stainless steel elbows, tees, couplings, reducers & adapters provide savings in time, labor & materials. Require only an Allen wrench for adjustment. Cooper Alloy Corp.

85R Phenoline 300. Protection of concrete floors & other installations accomplished by use of material. Good resistance to acids, alkalies, solvents. Carboline Co.

86L Antifoam Emulsion. This Dow Corning silicone defoamer restores productive capacity previously wasted on foam, reduces process time, prevents boilovers. Dow Corning Corp.

87R Heat Exchangers. Custom-built quality at the off-the-shelf price & delivery on semi-standard heat exchanger units. Downingtown Iron Works, Inc.

89TL Process Equipment. Processing units for pilot plant or special continuous or batch needs. Developed by combination of skills of chemical & mechanical engineers. Artisan Metal Products, Inc.

89BL Pyrometer. Designed to meet plant & laboratory surface & sub-surface temperature measurements. Large 4¾ in. direct reading scale. Pyrometer Instrument Co.

89BR Arched Wafers. A new process & service gives arched wafers many advantages over flakes or other shapes. Flakice Corp.

90L Dust-Tite Valves. Self-cleaning, free-flowing, Dust-Tite valves spherical shape are machined to close tolerances for accurate seating. General Machine Co. of New Jersey.

90TR Research. A service set up to accord occasional or constant research, with all equipment, experience, & facilities. Foster D. Snell, Inc.

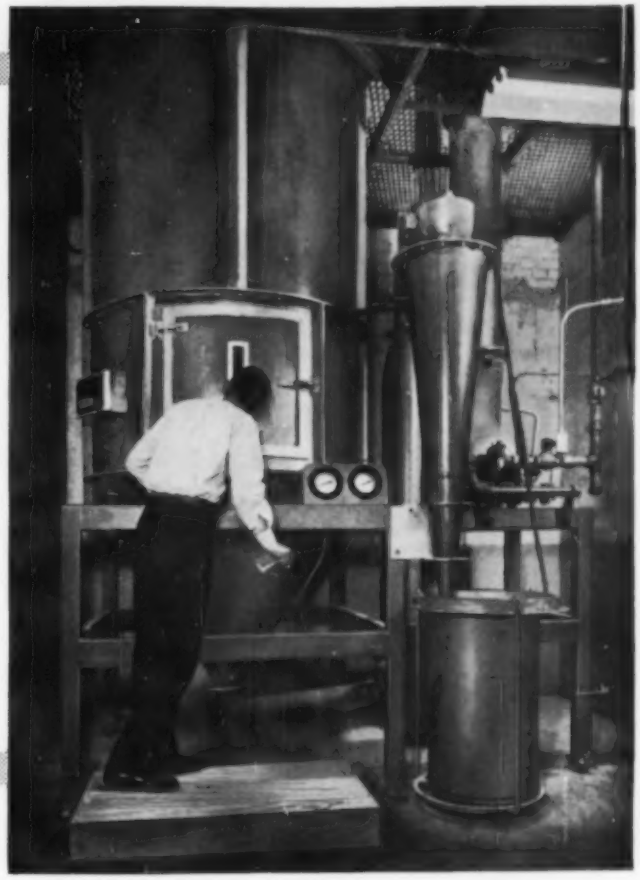
90BR Ejectors. Fabricated from carbon, Haveg, or Teflon as well as various metals, steam jet ejectors, condensers, vacuum equipment have interchangeable corrosion resistant parts. Jet-Vac Corp.

(Continued on page 54)

new

BOWEN SEMI-WORKS SPRAY DRYER

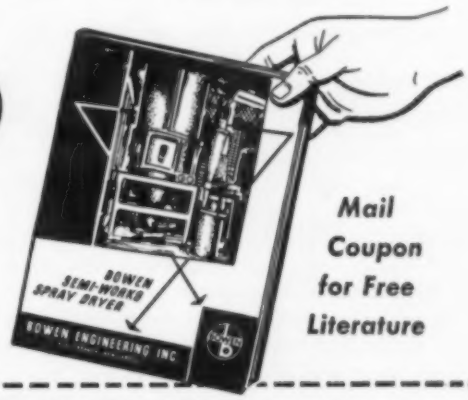
★ COMPACT
★ HIGH YIELD
★ EASY TO CLEAN
★ LOW OPERATING COSTS



From one position the operator can observe the chamber interior, read the inlet and outlet temperatures and adjust the air heater.

● **At last a fully prefabricated spray dryer requiring only hours to erect.** The new reasonably priced Bowen Semi-Works Spray Dryer makes available a small, compact unit requiring a working area of only 7 x 9 feet, completely prefabricated and transportable through usual factory openings. Surfaces in contact with the product and feed material are of stainless steel thruout. Drying temperatures are variable between 200°F and 750°F to accomodate a wide variety of materials.

An interesting illustrated booklet, Bulletin 36, is available. Send for it today.



Mail Coupon for Free Literature

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

Recognized Leader in Spray Dryer Engineering Since 1926

BOWEN SPRAY DRYERS
Always Offer You More!

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

Please send me Free Literature on Bowen Semi-Works Spray Dryer.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

PRODUCTS

(Continued from page 52)

91TR **Para Cymene.** An inexpensive stable medium for liquid or vapor heat transfer in range of 300 to 500° F. Newport Industries, Inc.

91BR **Laboratory Equipment.** Catalog & planning guide giving layouts, specifications, & ideas on modern laboratory furniture & equipment. Metalab Equipment Corp.

94TL **Filter.** Handles heavy residue products with ease. Discards cake in semi-dry state. Easy to open & clean. Sparkler Mfg. Co.

94BL **Technical Data Books.** Lefax pocket size, loose-leaf books on condensed, accurate, essential material for those in variety of fields. Lefax Publishers.

94BR **Production Mills.** Large-scale units for production of detergents, fertilizers, other materials in sizes 10 to 100 mesh, & as fine as 200 mesh. Gruendler Crusher & Pulverizer Co.

95BR **C-R Chill-Vactor.** Units flash cool water, aqueous solutions, & certain other liquids to temperatures down to 32° F. by partial evaporation at high vacuum. Croll-Reynolds Co., Inc.

106A **Filter Presses.** Flow rates of 2 to 5 times greater from a unit operated by one man. Does the work of two average size filters. Niagara Filters, Div. of American Machine and Metals, Inc.

IBC **Flow Control.** New approach to flow control solves low-capacity flow problems. Controlled volume pumps designed to meter & pump additives, other substances to 1% accuracy. Varied capacities & pressures. Milton Roy Co.

OBC **Lightin Mixers.** Control of shaft whip in mixing fluids one of advantages to be gained by use of these units. Mixing Equipment Co., Inc.

EQUIPMENT

1 **High Pressure Autoclaves.** New agitator called Dispersimax for use on pilot plant lines or laboratory high pressure autoclaves announced by Autoclave Engineers, Inc. Said to be a much improved method of promoting chemical reactions between gases, liquids, & solids. Forces small bubbles of gas at high velocity into & through liquid with suspended catalyst. Bulletin gives detailed information.

2 **Butterfly Valves.** Builders-Providence Inc. announce expansion of its line of butterfiy valves in color bulletin. Sets forth advantages, sizes, pressures, velocities. General arrangement dimension prints of various size valves with electric, manual, hydraulic, & pneumatic operators.

3 **Portable Mixer.** Gabb Special Products, Div. of E. Horton & Son Co. now produces a portable type mixer called Shear-Flow for mixing liquids & pastes. Developed for use in mixing viscous types of textile inks, now found to have many other applications in chemical industry in dispersion of paints, plastics, & gums. Consists of two impellers & a stator spaced closely together.

4 **Centrifugal Pumps.** Eco Engineering Co. announces that their stainless steel Centri-Chem (R) pump is now available with pedestal mount designed to permit belt drive or direct coupling with any standard motor. Used for handling of materials such as anti-biotics, viscous corrosives, hydrogen peroxide, & aromatic solvents. Previously offered as closed couple unit only. New mount said to be greatly extend versatility by attachment to all standard motors.

5 **Diffusion & Booster Pumps.** A line of oil diffusion & booster pumps said to have greatly increased pumping capacity over critical pressure ranges, introduced by F. J. Stokes Machine Co. Both series embody completely new design concept called Ring-Jet described as major advance in vacuum pump design. Both types available in sizes 4 to 16 in.

6 **Infrared Gas Aanalyses.** A 12-page illustrated paper from Perkin-Elmer Corp. outlines application of infrared methods to light hydrocarbon gas analyses. Gives details of procedure & calculations involved in typical 5-component analysis, outlines advantages of infrared & mass spectrometer methods, describes instrumentation, services, & laboratory space needed.

7 **Custom & Standard Alloys.** A new service to metalworking phase of aviation industry provides custom & standard high alloys in sample or production quantities as required by Cannon-Muskegon Corp. All alloys certified as to chemical content & physical properties where required. Bulletin explains MasterMet alloys.

8 **Storage Tanks.** Storage tanks with capacities of 50,000 lb. fabricated by Alloy Fabricators Div. of Continental Copper and Steel Industries, Inc. developed for a Government project represent unusual fabrication problems solved. Tanks are 11 ft. 6 in. diam., shop fabricated for shipment in one piece.

9 **Bin Vent Filter.** Called Ducon, meaning dust control, the type UFV filter produced by The Ducon Co. is described in illustrated folder. Applicable where enclosure should be maintained under slight vacuum, where product is retained in system & returned to process, & where displacement air, either from loading or conveying must be vented of free dust.

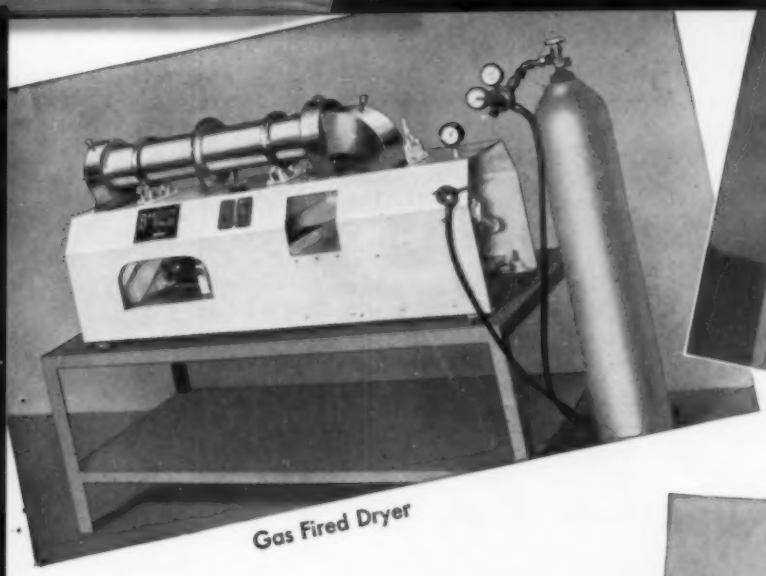
10 **Temperature Controller.** Performance specifications, application ideas & complete description of liquid-filled, remote indicating temperature controller available from Fenwal, Inc. Features easy adjustability of control band width. Can be set between 1% & 4% of scale. Operating range is 100 to 700° F. with uniform control characteristics & sensitivity maintained. Temperature-indicating pointer & set-point display pointer mounted on same dial face providing quick reference check of process temperature. Power relay rated at 15 amps., 115 v.

11 **Chemical Mixer.** New range of sizes & capacities from 1 gal./min. to 10,000 gal./min. announced for American Homomix continuous pipe-line chemical mixer by American Well Works. Eliminates mixing tanks or chambers in new plants & effectively improves mixing in existing setups. Folder shows cutaway view, capacity table, other details. Feature is versatility—ability to meet exacting requirements of chemical & other process industries for blending, washing, chlorinating in limited space.

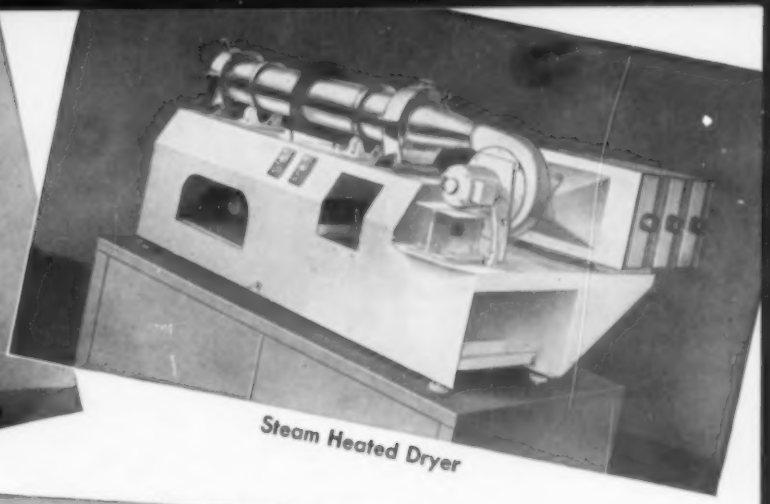
12 **Dry Fluid Drive.** Called Flexidyne a development in industrial power transmission described as a dry fluid drive, announced by Dodge Mfg. Corp. Said to easily handle difficult starting & reversing problems & provides new kind of protection against shock & overloads. Advantage said to be that it does not slip at normal operating speeds. Applicable for industrial drives involving heavy inertia & shock loads on compressors, centrifuges, conveyors, oil field machinery.

14 **Plug-In Receiver.** Claimed for the new Bailey Meter Co. plug-in pneumatic receiver are unlimited record grouping,

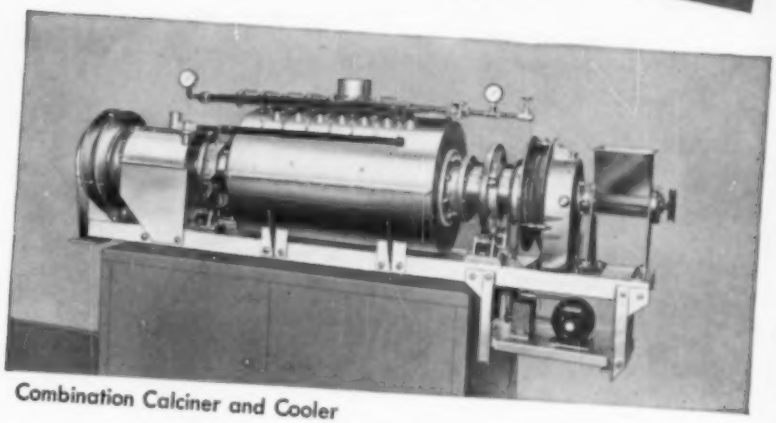
(Continued on page 56)



Gas Fired Dryer



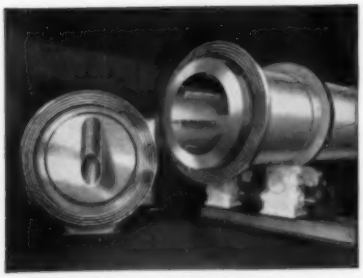
Steam Heated Dryer



Combination Calciner and Cooler

DON'T GAMBLE!

Test run your products in our experimental Dryers and Calciners



Labyrinth Seal on 60" x 32' 0" Stainless Steel Plastics Dryer showing the Mirror-like Finish on the Shell and Flights.

Special Stainless Steel Batch Dryer for Drying Fine Catalyst without Dust Loss.

• Establish definitely the heat sensitivity, permissible temperatures, entrainment losses, desirable velocities, "balling", sticking, cooling and all other chemical and physical aspects of the heat processing project *before* you build the production unit.

Our experimental and development laboratory can really save you time and money. In addition to the continuous gas-fired and steam heated dryer (operated parallel or counter-flow) and the continuous combination calciner and cooler shown above, the laboratory is also equipped with a steam jacketed batch pot type dryer, screening and other accessory facilities.

Send us samples of your products. Tell us the conditions and let our technicians make the test runs, preferably with your representatives present. All the test units illustrated have been standardized and are available for purchase by concerns maintaining their own testing laboratories.

DESIGNERS

ENGINEERS

BARTLETT-SNOW

CLEVELAND 5, OHIO

FABRICATORS

ERECTORS

Dryers • Coolers • Calciners • Kilns

"Builders of Equipment for People You Know"

EQUIPMENT

(Continued from page 54)

shelf-to-operation simplicity, & drift-free stability. Arbitrary mounting of one to four identical units made possible by plug-in, pin-positioned construction & unique indexed drive arm. Signals may be graphically recorded from any pneumatic transmitter with 3 to 15 lb./sq.in. gage or 3 to 27 lb./sq.in. gage ranges.

15 **Vinyl Paint.** Hot spray applied vinyl-based protective coating that builds film thickness in two coats equal to five of cold spray vinyl coatings, announced by U. S. Stoneware Co. Called Tygon ATD it combines vinyl & other plastic resins to form high solid content viscous material which reverts to liquid form on application of heat. Avoids excessive amount of solvents to achieve spraying consistency. Spark testing shows complete absence of pin holes. Labor costs said to be reduced 20%.

16 **Chart Paper.** Foxboro Co. announces perfection of new type chart paper with special properties to improve legibility of instrument records. Humitex circular & strip charts are printed under controlled humidity conditions on white sulphite sheet. Meet rigid standards. Scale markings & time arcs printed in gray for contrast with colored recording inks. For use with new sediment-free ink & stainless steel pens. Sample chart available.

17 **Relief Valves.** For unfailing operation under all service conditions, multiproof relief valves with vapor cushioned multiple valve disc construction. Product of Cochrane Corp. valves are designed to provide safe, smooth relief of overpressure in systems or equipment, & eliminate waste of steam, air or gas by over-relief. Design causes valve discs to hold tight against operating pressures. Sizes 4 to 48 in. in vertical up-flow, horizontal or angle types.

18 **Industrial Corrosion Protection.** Pennsylvania Salt Mfg. Co. has introduced a new resin coating for industrial corrosion protection for surfaces exposed to humid & corrosive atmospheres. Called Thick-Coat product is combined with their high bond strength primers to ensure adhesion. Provides durable protective coating for new or corroded metal, concrete & wood equipment, structures exposed to fumes. Good flow qualities.

19 **Rotary Seal Cartridge.** An easily-replaceable cartridge assembly for use with rotary mechanical shaft seals developed by Mixing Equipment Co., Inc. Positive, leakproof sealing of tank liquids, vapors or gases is provided. Seal requires no adjustment while in service. Called Lightnin & assembled in cartridge as single component. Data sheet showing cutaway view, available.

20 **Laboratory & Pilot Plant Heat System.** Small heat transfer system for laboratory or pilot plant use now available from Bethlehem Foundry & Machine Co. Beth-Tec E. H. series heat transfer unit uses DuPont Hi-Tec eutectic salts as circulation medium. Temperature range 650 to 1,000° F. may be reached without pressure. Several standard sizes ranging from output of 10,000 Btu/hr. to 250,000 Btu/hr.

21 **Teflon Filter Media.** Bulletin from Porous Plastic Filter Co. on performance data on porous Teflon filter media, information on complete filter units using this new fluorocarbon material. New media said to make practical, former impossible applications. Data on pore size, flow characteristics for air & water, information on thermal & mechanical properties of porous fluorocarbon. Selection criteria included.

22 **Irradiated Polyethylene Extrusions.** Irradiated Aeroflex (polyethylene) now fabricated into crosslinked tubes, extruded shapes, or rods for test & development programs, by Anchor Plastics Co., Inc. Custom extruded in each case. Of special interest to chemists & the chemical industry.

23 **Production Line Models.** Simplified models of machine tools & auxiliaries at low cost available from Industrial Models, Inc. Sizes range from ⅛ to ½ in. to the foot. Folder gives answers to questions on layout models as to cost, quality, availability, available scales.

24 **Plug-In Controller.** A millivoltmeter controller housed in a horizontal case introduced by Mineapolis-Honeywell Regulator Co. Available in three control forms—on-off, two-position, & three-position. Three-position control incorporates dual index & provides neutral zone adjustable from 0 to 100% of full scale, or 0 to 10% of full scale. Calibrated accuracy ¾% of full scale.

25 **Plastic Pipe & Fittings.** Full-scale production & distribution of Poly-Gem flexible lightweight plastic pipe, fittings & stainless steel clamps in sizes from ½ to 3 in. I.D. from Acme Rubber Mfg. Co. Pipe is 100% polyethylene, immune to rot & rust, & electrolytic corrosion. Made to specified diameters & wall thicknesses—not drawn to reduced sizes. Resistant to acids, alkalis & metallic salts. Non-toxic & resistant to growth of bacteria & molds. Recommended for transmission of beverages, juices, other products in food-processing systems.

26 **Heaters.** Line of standard heaters from Rempe Co. Called Hi-Therm grid heaters for maximum, high speed, efficient heating of solutions in plating, rinse, cleaning or caustic tanks, & for general fluid heating service. Cross sectional width 2¾ in. High concentration of heating service said to make units superior to plate coils by promotion of agitation within solution being heated. Standard height 31½ in.; lengths as required. Tested pressure 350 lb.

27 **Pocket Size Calculator.** A reliable handy pocket size slide-rule type calculator showing comparative fuel costs of coal, gas & oil, announced by Hev-E-Oil Burner Div. of Cleaver-Brooks Co. & available upon request.

28 **Aerosolve Filter.** Cambridge Filter Corp. literature available on Aerosolve & Absolute filters. For use in comfort air conditioning systems, in offices, commercial buildings, & industrial plants, as well as process applications, Aerosolve. For use in control of radioactive air & similar purposes, Absolute. Detailed information on capacities, efficiency, other details of both.

29 **Cooling Tower Accessories.** Multiple blower tower assemblies with individual motor drives for use with series 3-B cooling towers from Binks Mfg. Co. Illustrated bulletin explains design features which make these towers almost noiseless & protect fan assembly from corrosion by placing air-propulsion unit in dry air stream. Rating tables show possibilities of cooling with these towers. Data supplied for wide range of operating conditions covering tower capacities of from 2 to 3 tons of refrigeration for residential installations to 360 tons for large buildings.

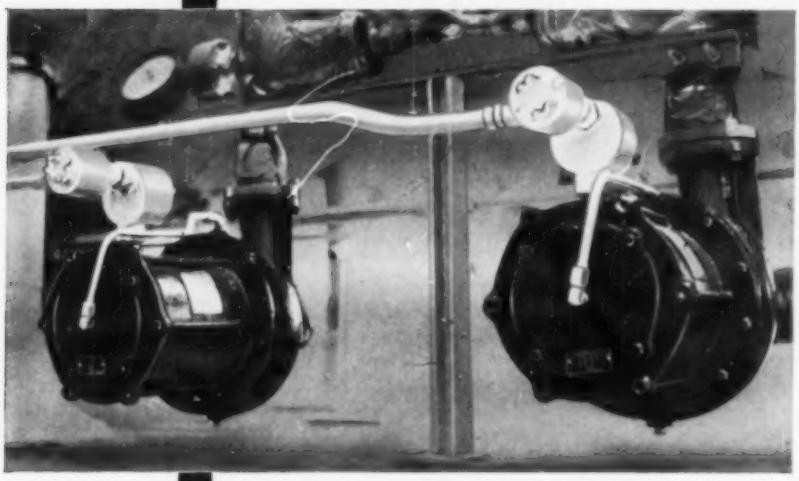
30 **Hastelloy Pump Internals.** Eco Engineering Co. synthetic rubber pump is now available with Hastelloy-B or Hastelloy-C shaft, eccentrics, & guides. Hastelloy-B permits handling of boiling hydrochloric, sulphuric & mixed acids; Hastelloy-C extends pump service to highly oxidiz-

(Continued on page 58)

Chempump

handles problem fluids without failure or leakage of any kind...

at large midwestern chemical plant



Two 2-hp. *Chempumps* on 0°F service, handling liquid which tends to polymerize on contact with air . . . thereby forming hard crystals which could cause operational trouble with ordinary pumps.

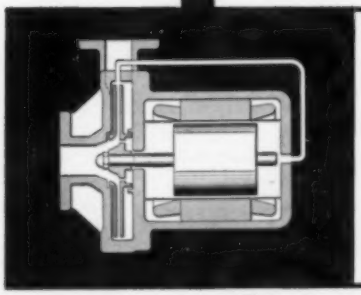
PROOF through *performance* is what sold this big chemical company on seal-less, leak-proof *Chempump.*

In one particular process, one man was kept busy just maintaining seals on small centrifugal pumps. When the *Chempump* was introduced, problem fluids were handled without failure or leakage of any kind. So far, maintenance has been no problem. The service these seal-less pumps have given is felt to more than justify the higher initial equipment outlay.

This is just another example of how *Chempump* has licked tough leakage problems! With this seal-less combined motor and pump unit, normally hard-to-handle fluids can't leak or become contaminated. Periodic inspection to indicate necessity of simple bearing change is the only maintenance required.

Your process can benefit through *Chempump*, too. For details, send for new 16-page Bulletin 1010. Chempump Corp., 1300 E. Mermaid Lane, Phila. 18, Pa.

Engineering representatives in over 30 principal cities in the United States and Canada.



Chempump combines pump and motor in a single hermetic unit. Pumped fluid enters rotor chamber; no shaft sealing device required.

Approved by Underwriters' Laboratories. Available in wide choice of materials . . . from ⅙ to 7½ hp. Capacities to 250 gpm. Heads to 195 feet.

Chempump can't leak!

Please send me details on *Chempump* for:

_____
(application)

*Capacity*_____ *Total dynamic head*_____

*Name*_____

*Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

Chempump —

first in the field . . . process-proved

EQUIPMENT

(Continued from page 56)

ing acids & agents such as free chlorine & bleaching compounds. Pump is a positive displacement oscillating rotary type. Capacities to 10 gal./min.; pressures to 100 lb./sq.in. realized at sustained 1,725 rev./min.

CHEMICALS

40 **Various Chemicals.** Harshaw Chemical Co. chemicals for industry & laboratory are listed and described in new brochure. These include catalysts & catalyst chemicals, fluorides, driers & metal soaps, pigments, synthetic optical crystals, agricultural chemicals & others.

41 **n-Butyl Benzoate.** A new technical bulletin from Carbide and Carbon Chemicals Co. on n-butyl benzoate. Material is economical source of the benzoic group for chemical syntheses by ester exchange. Information given on properties, resin solubilities, applications as a solvent or extractant & as intermediate for benzoate esters & alkyd resins.

42 **Sesquicarbonate of Soda.** "SnowflakeCrystals and Snowfine," a comprehensive booklet on sesquicarbonate of soda offered by Solvay Process Div. of Allied Chemical & Dye Corp. Highlights the many commercial potentialities for the product. Carries tables & graphs, covers physical & chemical properties.

43 **Alkylanilines.** Two new alklanilines available in pilot plant quantities from Monsanto Chemical Co. Compound C-5 has an average of five carbons for the ring-substituted alkyl group; C-12 averages 12 carbons. Technical data sheets available suggest chemicals be evaluated as intermediates for use in petroleum, agricultural & pharmaceutical applications.

44 **Calculation of HLB Numbers.** Pamphlet now available from Atlas Powder Co. reveals their method for calculating HLB numbers of nonionic surface active agents. Numbers indicate if material is hydrophyilic or lipophilic. Choice of material for a specific purpose can often be arrived at by correlating desirable HLB range for any given application with published HLB numbers of certain agents.

45 **Resin Review.** Published for users of synthetic resins by Rohm & Haas Co. book contains information on certain coatings, a new acryloid; information on plasticizers.

46 **Gamma-Dimethylaminopropyl Chloride Hydrochloride.** Now available in commercial quantities gamma-dimethylaminopropyl chloride hydrochloride. Material has never before been available in the U. S. A non-toxic compound it is of interest principally to the pharmaceutical industry as an intermediate. Michigan Chemical Corp.

47 **Liquid Polymer Emulsions.** Methods of preparing stable, water-based emulsions from Thiokol liquid polymer have been developed by Thiokol Chemical Corp. & set forth in brochure. Emulsions are fine particle size and potentially suitable as binders & impregnants for wood, paper, textiles, felt & other water absorptive materials.

48 **Neoprene W.** Addition of neoprene W to its line of corrosion resisting protective coatings announced by Carboline Co. A one component neoprene synthetic coating easily applied by brush or spray. Curing done at room temperature. Recommended for maintenance protection against most acid & alkali fumes & splash & high humidity.

49 **Silicone Parting Agent.** A super-stable silicone parting agent for rubber, plastics & metal introduced by Dow Corning Corp. Called Mold Release Emulsion 36, it is said to be more resistant to creaming or separation than any comparable silicone emulsion yet developed. Tests show that emulsion will not break even after 168 hr. at 158° F. or after eight freezing & thawing cycles, or after recirculation through a centrifugal pump.

BULLETINS

55 **Portable Spray Dryer.** Built primarily as an instrument for research both scientific & technical, indicates what happens when particular substances are spray dried. Atomizer wheel of minor unit produces finer powder than industrial plant wheel. Homogeneiity feed requirements are stricter. Folder shows cutaway view & gives other data. Niro Atomizer Ltd.

56 **Chemical Plants.** Efficiently designed & constructed chemical plants built by Kaiser Engineers, Div. Henry J. Kaiser Co. are subject of well illustrated brochure. Illustrates diversity of accomplishment from extraction of magnesia from the sea to production of filter aids from diamotaceous earth.

57 **Fabricated Metal Products.** Pressure vessels, prefabricated pipe, welded structures available to industrial & construction firms from Fluor Corp., Ltd. Staff available for design of specific products or equipment. Well illustrated bulletin shows facilities & products available plus tables giving details on equipment.

58 **Vacuum Pumps.** Model KMB mechanical booster high vacuum pumps, two-stage construction from Kinney Mfg. Div., New York Air Brake Co. described in brochure. No sealing fluid in first stage thus producing clean, fast pumping speed with low power consumption. Operating characteristics in various fields explained. Tables of sizes, weights, capacities.

59 **Polyvinyl Chloride Sheet.** Especially adapted to the production of corrosion-resistant tanks, ducts, & similar structures by welding, rigid polyvinyl chloride sheet. Material has high impact, tensile, flexural & welding strengths combined with good resistance to chemicals & moisture, & has a high distortion point. Easily machined & fabricated. Bakelite Div., Union Carbide & Carbon Corp.

60 **Cement.** Haveg 6310 a carbon filled furan resin composition cement developed for laying brick & tile floors & similar uses in the chemical processing areas. Bulletin includes general information, description, physical properties, tables. Haveg Corp.

61 **Mix-Mullers.** A 12-page bulletin from National Engineering Co. answers questions about mulling in addition to describing applications and uses of the Simpson Mix-Muller in preparation of dry, wetted & plastic mixtures. Included are a description of the mulling principle of mixing; outline of mulling as practiced in various industries; & detailed specifications on 13 models in the new series.

62 **Plastic Pipe & Fittings.** How to use & specify rigid plastic pipe & fittings is discussed in new catalog of standard line offered to design, maintenance & application engineers by Alpha Plastics, Inc. Reference facts on its ½ to 4 in. line of normal impact & high impact unplasticized polyvinyl chloride pipe & fittings, plus properties & characteristics data, as well as drawings & specifications for various types of fittings.

(Continued on page 60)

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

Pfaudler announces new UTILITANKS for storage!

Glassed both sides, they won't rust, never need painting

NEW PRODUCTS TO HELP YOU FIGHT CORROSION

DRYER-BLENDER

New Pfaudler glassed steel conical dryer-blender permits drying corrosive products in as little as 1/5 time previously required. See story below.

UTILITANKS

Glassed inside and out with a mild corrosion resistant glass, these storage tanks are low in first cost and easy to clean. See story at right.

New Glassed Steel Dryer-Blender

Does 4 Days' Work in 7 Hours!

Now you can speed up drying of highly corrosive products. New Pfaudler glassed steel conical dryer-blenders give you the speed of a conical dryer *plus* the corrosion resistance of acid-alkali-resistant glassed steel.

For example, a large manufacturer recently began using one of these new dryers for a product containing acid halides. The new Pfaudler unit has reduced drying time of this highly corrosive product from 4 or 5 *days* to 6 or 7 *hours!*

Less Labor Time

They saved most of the time previously spent in handling trays of vacuum tray dryers. Filling and emptying a Pfaudler conical dryer-blender is quick and easy. It has a 1½-foot diameter opening for filling, and a single 8" discharge nozzle.

When in use, the dryer slowly revolves, tumbling its contents and quickly providing an evenly blended, evenly dried product.

To speed the process, heat is applied throughout the jacket by hot water, vacuum steam or pressure steam, and a vacuum exhaust constantly draws off vapors.

Freedom of Use

You can use Pfaudler conical dryers for every acid except hydrofluoric, and for alkalies up to pH 12 at 212° F. Thus you get the same flexibility you are already familiar with in Pfaudler glassed steel reactors, heat exchangers, columns and other equipment for tough corrosion jobs.

These dryers range in volume up to 150 cu. ft. working capacity. They are available in four different diameters: 2-ft., 4-ft., 6-ft. and 8-ft. diameters. Internal pressures may range from full vacuum to 20 psi. Maximum jacket pressure 20 psi with full vacuum. Each unit tested to meet ASME code specifications.

Send coupon for further details about fast moisture-removal with Pfaudler conical dryer-blender.

These new low-priced Pfaudler UTILITANKS have a smooth, non-oxidizing glass surface inside and out.

On the inside, this glass protects your product from contamination because glass will not oxidize, flake or deteriorate with age.

On the outside, the glassed surface means you never have to paint the tank. It won't rust. Over the years, you'll save hundreds of dollars in upkeep costs.

Fast, Easy Washing

Cleaning is easy, too, because Pfaudler glass is smoother than the most highly polished stainless steel, and practically nothing sticks to it. Just hose it down.

Beneath these glassed surfaces is a rugged carbon steel tank which gives you the structural strength necessary for day-in, day-out use. The glass is not simply a coating or layer of enamel—it is actually *fused* to the steel in Pfaudler's furnaces at 1600° F. This results in a bond of interlocking glass and steel so strong that our tests could not separate them with a pull of over 1500 lbs./sq. in.

Low-Cost Storage

UTILITANKS are low in cost. We've left off fancy gadgets and used glass perfectly suited for such products as paint, wax, antifreeze, ink, liquid sugar, and other neutral products. Sizes range from 1000 to 5000 gallons, and your initial investment can run as low as 50¢ per gallon capacity.

You'll want to see Bulletin 916 which tells what products may be stored in UTILITANKS, what sizes are available, what they weigh and what features are provided as standard. Mail the coupon today.

THE PFAUDLER CO.,
Dept. B-3, Rochester 3, N. Y.
Please send data on ☐ UTILITANKS
☐ Dryer-Blender ☐ Other equipment

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State____

BULLETINS

(Continued from page 58)

63 **Totally-Enclosed Motors.** An improved motor for dangerous duties completely sealed & ruggedly armored, from U. S. Electrical Motors, Inc. is described in illustrated folder. Features shock-resistant, cast iron frame, prewound stator core, electronically-balanced rotor, plus a special slinger which bars moisture. Cutaway views plus other pertinent data.

64 **Titanium Tubing & Piping.** From Carpenter Steel Co. a bulletin on titanium tubing & piping. Considers advantages, production tests, physical properties, applications, corrosion resistance, & machining. Two grades one with yield strength of 55,000 lb./sq.in., the other with 70,000 lb./sq.in.

65 **Engineering Facilities.** Vitro Engineering Div. of Vitro Corporation of America in an illustrated brochure describes its engineering facilities beginning with studies for feasibility & economics on through engineering, to completed facility.

66 **Sectional Laboratory Furniture.** The reasons which enable Metalab Equipment Corp. can make immediate delivery of laboratory furniture are set forth in a bulletin. Various items of equipment are listed, together with all types of accessories which complete the laboratory.

67 **Operating Valves.** Quick opening operating valves from Leslie Co. including manually operated air & water valves, remote operated shutoff valves, & electric solenoid valves are dealt with in a binder insert bulletin. Variety of available types & sizes in each group, details of construction & use.

68 **Piping Products.** Catalog 54 from Midwest Piping Co., Inc. is a one-source reference book for technical data on piping standards, codes & specifications. Data on design & layout of piping systems. Covers 192 pages of information.

69 **Liquid Chillers.** From Worthington Corp. binder insert catalog on packaged liquid chillers for air conditioning & industrial application. 7½ to 80 h.p.—factory assembled; 100 to 150 h.p. field connected. Heart of these units which require a minimum of floor space is the Worthington compressor.

70 **Cast & Forged Steel Valves.** A catalog from Edward Valves, Inc. covers all types of cast & forged steel globe & angle stop, non-return, & other valves & strainers for steam generating stations, technological & process installation, & oil drilling rigs.

71 **Liquid Handling.** Allis-Chalmers Mfg. Co. offers aid of experienced application engineers to solve your liquid handling problems. At no cost to you they will supply all material required to operate efficiently a pump & power package, which is guaranteed. Capacities to 10,000 gal./min.; heads to 600 ft.; temperatures to 800° F. Includes process, general purpose, & solids handling pumps.

72 **Gas Turbines.** Comprehensive illustrated binder insert catalog from General Electric Co. on their combustion gas turbines in simple-cycle single-, & two-shaft, & regenerative-cycle, two-shaft types for power generation & mechanical drive.

73 **Storage Tanks.** Buffalo Tank Corp. fabricators of tanks for the chemical & processing industries also supply custom made equipment for the oil refining & other industries. Welded steel plate products for every industry as shown in illustrated folder meet many codes & specifications. Carbon steel, corrosion resistant steels, stainless, clad, nickel and other materials fabricated.

74 **Valves, Pumps & Fittings.** Loose leaf binder catalog from Pressure Products Industries covers line of high pressure valves, fittings, pumps, intensifiers, etc. Cutaway views, construction details, all pertinent information on individual items.

75 **Gyrating Screen.** Model C screen 3 ft. x 8 ft. provides full 24 ft. of screening surface. Completely balanced assembly concentrates vibration to deck area with little transmitted to main frame. Unit weighs 1,000 lb. Unit is tapered at discharge end to fit existing conveyors. Fabricated with either stainless steel screen cloth or mild steel deck & spring steel screen cloth. Welded parts normalized to relieve stress. Simplicity Engineering Co.

76 **Thermal Liquid Heaters.** International Boiler Works Co. LaMont thermal liquid heaters incorporate LaMont principle of forced recirculation, provide a process system temperature to 750° F. with close tolerances ±2°. By maintenance of fluid velocities of 5 to 8 ft./sec. within tubular heating surfaces of heat maximum heat absorption & operating economy obtained. Specific features described in bulletin.

77 **Ball Mill.** Pilot plant grinding simplified with use of Denver Equipment Co. steel head ball mill. Mounted on steel base for flexibility. Shell sections may be added or removed as required to duplicate mill problems. Same base for mill of one or two sections. Feed by scoop or feed plate may be removed to feed by launder, chute or pipe. Other mills for pilot plant & commercial grinding.

79 **Aluminum Digest.** Growing applications of aluminum in the process industries are described in an 8-page booklet from Aluminum Company of America. Outlines economic & technical advantages of this material when used in processing equipment for chemical & material storage, & for transporting liquids.

80 **Electrical Precipitation Equipment.** 28-page bulletin from Research-Cottrell, Inc. covers electrical precipitation equipment. Describes general principles of electrical precipitation. Individual sections devoted to chief applications. Installation photographs & diagrams shown.

81 **Jet Apparatus.** Engineers will be aided in selection of the right type of jet apparatus for specific requirements by use of bulletin J-1 from Schutte and Koerting Co. Includes basic information on the jet principle, jet apparatus terminology, plus data on jet construction, operation & advantages. Function of apparatus outline, types suited to each function identified, & each type described.

82 **Dispersion Problems.** Loose-leaf binder from Kinetic Dispersion Corp. devotes 43 pages to discussion of dispersion problems for chemical processes in industry. Contains comparison charts of results of various methods in relation to use of their Kady Mill plus other vital technical data. Operational information on formulas for certain Kady Mill coating materials. Contains inserts which are coated with Kady Mill products.

83 **Rayotube Detectors.** For continuous temperature measurement in many industrial applications & often where other methods prove impractical, Leeds & Northrup Co. Rayotube detectors provide sensitive, stable, & highly responsive temperature sensing elements. Respond to radiated heat energy & can measure the temperature of either stationary or moving surfaces. Bulletin insert.

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Walt Whitman

The famed chemical engineering teacher and consultant—who "knows who can do what needs to be done"—has been given a top U.N. job . . . will organize and manage International Atoms-for-Peace Conference at Geneva, Switzerland.

Walter Gordon Whitman, head of the department of chemical engineering at Massachusetts Institute of Technology . . . adviser to the Atomic Energy Commission . . . former War Production Board chemicals official, has been made Conference Secretary-general of the Atoms-for-Peace Conference to be held in Geneva, Switzerland, this August. The appointment was made by Dag Hammarskjold, Secretary-general of the United Nations.

In an exclusive interview, Walt Whitman (as he prefers to be known by his professional associates), just four days in office, greeted the editors of C.E.P. in his office high in the U.N. Secretariat Building overlooking Manhattan Island.

In his easy manner, slightly New England in reserve and wit, Walt Whitman explained how he came to be selected for one of the highest posts in the U.N. atomic program. "I seem to get into things according to a pattern. In this case, Mr. Dag Hammarskjold first asked me to assist Under-secretary Ralph Bunche to prepare for a meeting of an advisory committee to try to set up a resolution on the assembling of a conference on the peacetime uses of atomic energy for the consideration of the U.N. I said I'd help. At the end of this committee meeting and after an organizational plan had been decided on, Mr. Hammarskjold offered me the post of Conference Secretary-general. Believing as I do in the great constructive potential of the Conference, what could I do but take it on?"

"The Atoms-for-Peace plan offers a wonderful opportunity . . ."

"Taking it on" represents the second time that Professor Whitman failed to practice what he had preached to the faculty of M.I.T. in 1951, when he gave a speech about "our responsibility to be of any help that we might to the Government but without running away from M.I.T." One month after this speech Professor Whitman was tapped for the position of chairman of research and development for the Department of Defense, a job that took him to Washington for two years.

The present job of organizing and managing the Conference would be staggering to most men, but not so to engineer-diplomat Whitman. At present, he is calmly considering accommodating the 86 states which have been invited (including members of the U.N. plus states which are members of specialized U.N. agencies, the category into which West Germany falls); the soliciting and screening of hundreds of technical and scientific papers; and the problems of communication (both printed and spoken) in four languages. The job, he says, reminds him of some of the other instances when he has taken on projects before exploring their full implication.

Walt Whitman's preparation for this huge dissemination of atomic energy information began when his teaching career got underway. "There's no better way to get to know the successful young engineers of the country than to turn them out as your own students," he explained. Actually his career of public service started in 1940, when Vannevar Bush decided that the structure of the N.A.C.A. was due for an overhaul to prepare it for a possible shooting war. Soon Whitman was formulating advice about setting up an aircraft fuels and lubricants committee. Once his advice was rendered, Walt was asked to be chairman of the committee—and "what could I do after sticking my neck out that far, but accept?"

Expecting to launch a research program, Walt Whitman found his committee had to plunge immediately into estimating the supply of fuels and lubes to serve the 50,000 prospective planes which President Roosevelt had dramatically announced. Whitman's report, written in the midst of an Alabama vacation—"a family reunion involving 32 in-laws, children, and grandchildren"—was turned down by the military as calling for too large a figure. Fifteen months later the military was very much aware of the validity of the estimate and was "raising hell to get it." By early '41 it seemed clear to Bob Wilson—who was not only handling all War Production Board petroleum planning, but also heading a petroleum firm—that Walt

Whitman didn't have a big enough job. So, "according to pattern," Bob asked Walt to help a bit during the summer. After Pearl Harbor Walt was asked to accept the post of full-time director of the Basic Chemicals Section of W.P.B. "At a time like that, how could anyone refuse?" he reminisced.

As top executive over basic chemicals allocations, Walt had many products and pressure groups to contend with. "None were as bothersome as ethyl alcohol, though. Alcohol was probably only about 10% of the job and really the only part of the job that was political. When other people tried to look over your shoulder and criticize, you could always scare them off by saying, 'hexamethylenetetramine, but you couldn't do that on alcohol. Everybody knows what alcohol is.' The alcohol was needed to make butadiene for the synthetic rubber industry, and by the end of the war, distillers, who had directed all their output to the butadiene plants, were left with very short whisky reserves, about which they wanted something done. Having to appear before a long series of committees studying the alcohol production and allocation situation for several years, Walt Whitman entered the foray with a large measure of Yankee shrewdness—"making darned good and sure I told a consistent story, no matter who was asking for it."

His return to teaching coincided with the beginning of the large veteran enrollment and was allowed to continue peacefully until April, 1948. In that month the A.E.C. and the Air Force came to M.I.T., explaining that they were faced with quite a problem. This was whether to push the development of nuclear-powered planes. "I happened to be one of a small group that listened to the story and argued that it was our duty to help them evaluate the situation. You know what happens when you argue *for* something like that—the next thing you know they have you taking on the job."

During the summer of 1948 Walt Whitman found himself heading up the top secret "Lexington Project." This was his first, but not last, contact with atomic energy. After four months the 45-man staff produced a report calling nuclear-powered aircraft "feasible." After this, in the fall of 1950, he was asked to be a member of the General Advisory Committee of the A.E.C. Then one day in 1951 his telephone rang and Robert Lovett, Deputy Secretary of Defense under General George Marshall, asked Dr. Whitman to lunch with him and the General. "Suddenly I found I was in Washington as chairman of research and development—which turned out to be a two-year hitch (August '51 to August '53)."

(*Continued on page* 64)

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WALT WHITMAN

(*Continued from page 63*)

Now, still serving on the A.E.C. Advisory Committee, Walt Whitman explains its function as "involving almost any topic of interest to the Commission's business where engineers and scientists, acting as a committee, can be helpful in giving their views." He then commented pointedly, "We don't, thank God, get into questions of power contracts. . . ."

Today Walt Whitman possesses a broad background mixture of chemical engineering consultation, teaching, and administration. In commenting on the future for chemical engineers in the nuclear field, W. W. commented, "I see quite a demand for the chemical engineering approach." By this he meant, first, the use of chemical engineering techniques (such as for the separation of products of fission appearing as fuel "poisons") and, second, the chemical engineer's way of solving problems.

In this latter connection he said, "While not wishing to oversell the idea of the chemical engineer's importance in nuclear engineering, I will say that he has shown a willingness to try something new . . . which has been a big reason why nuclear engineering and the chemical engineer have become so interrelated.

"I try to tell chemical engineering students graduating from Tech," he continued, "that when they get out on their own they should forget as fast as possible that they are *specifically* trained as chemical engineers. Instead, they should think of themselves as being trained to tackle new problems. I say, 'Don't ask whether this problem you've got to handle is in the field of your specific training. Tell yourself that a chemical engineer can do anything—and that if you don't know enough about it, remember that you can learn real fast. . . .'"

"The next thing you know, you've got the job . . ."

Citing the chemical engineering departments of M.I.T., Michigan, and Penn State for the inclusion of nuclear engineering programs in their graduate curricula, Walt Whitman the professor sincerely hopes that such graduate training will be sought by men from a variety of undergraduate backgrounds. "This nuclear business calls for the talents of men of so many different specialties . . . besides, recent history has shown some of our most successful engineers, scientists, educators and businessmen received university training in some other subject than their ultimate specialty.

"The fact," he continued, "that you see so often the fellow who has had chemical engineering in his background becoming a leader, not necessarily in chemical engineering, speaks well for the profession."

FACT-OUTLINE ON INTERNATIONAL CONFERENCE ON PEACEFUL USES OF ATOMIC ENERGY

Where: Geneva, Switzerland

When: August 8 through 20, 1955

Participants: 86 States

Sponsorship: United Nations

Secretary-general of U.N.: Dag Hammarskjold

Conference Secretary-general: Walter G. Whitman (U.S.)

Assisting Committee: R. J. Bunche, Gunnar Randers, I. S. Tchernychev

Conference President: Homi Bhabha (India)

Vice-presidents: Six, to be appointed by Secretary-general of U.N.

Who May Participate: Not more than five appointed representatives from each state, plus as many advisers as may be required

Agenda Highlights: Need for new power source . . . role of nuclear energy . . . reactor enterprise organization . . . research power reactors . . . fuel element prospecting . . . fuel production, metallurgy . . . reactor physics, chemistry & metallurgy . . . biological uses & problems (radiation) . . . health & safety . . . isotopes & radiochemicals . . . nuclear physics . . . personnel training

In concluding the interview, Walt Whitman the philosopher . . . teacher . . . public servant walked over to his large window overlooking the New York skyline and stared out into the setting sun. "It is very important for us to keep in mind," he mused, "that the primary objective of the Geneva Conference is to give us an opportunity to do something constructive about the peaceful use of atomic energy. It's unusually important because so far its demonstrations to the world have largely been destructive. We know only one thing about it with certainty—it can be completely catastrophic.

"It is worth great effort on our part to try to demonstrate peaceful application. . . . There is a great psychological factor involved in getting the people of the world—our own countrymen included—to believing in this new force as constructive rather than purely destructive. President Eisenhower's Atoms-for-Peace plan offers a wonderful opportunity to actually do something that may bring about a turning point toward a better, more hopeful tomorrow for the peoples of the world."

ENGINEERS' JOB DIRECTORY AVAILABLE

Engineer's Job Directory, a new annual publication, has been recently published by Decision, Inc., 105 East Fourth St., Cincinnati, Ohio. The directory is designed to help many of the nation's top companies present their story to the graduating engineer.

The EJD helps the engineer research the job market. One hundred twenty-nine companies are participating in presenting key facts about their organizations. These facts include type of industry, products manufactured, number of employees, and whom to contact. Companies indicate the type of engineers they want. The price of EJD is $2.25.

ONE WAY TO ATTACK ENGINEER SHORTAGE

Concern over the continuing shortage of engineering and science graduates has been the reason behind the Philadelphia-Wilmington Section of A.I. Ch.E. issuing a Scholarship Directory. This 24-page booklet lists opportunities relating to Bucknell, Drexel, Lafayette, Lehigh, Princeton, U. of Delaware, U. of Pennsylvania and Villanova.

Directory is available for high school students. Copies are obtainable from W. T. Dixson, Atlantic Refining Company, 260 S. Broad St., Philadelphia 1, Pa.

ROME TO HAVE PETROLEUM CONGRESS

The fourth world petroleum congress will be held in Rome, Italy, next June. It is expected that there will be more than 3,000 participants in the congress representing major scientific and engineering personalities.

The meeting will cover subjects such as regional geology, geology of reservoirs, the origin and accumulation of reservoirs and other geological and geophysical topics pertaining to petroleum.

AUTOMATION SYMPOSIUM

"Automation-Engineering for Tomorrow" is the theme of a symposium to be held May 13, 1955, at Michigan State College. The chemical engineering phase of the program will be concerned with automatic composition control.

CONFERENCE ON BIOLOGICAL WASTE TREATMENT

The principles of biological waste treatment processes and the design of waste treatment facilities will be presented at a three-day Conference on Biological Waste Treatment to be held at Manhattan College from April 13 to 15.

"MIGHTY MITE" SOLVES CHEMICAL PUMP PROBLEMS

The Eco All-Chem Pump is the All-Teflon and stainless steel pump that handles 70 percent of corrosive chemical requirements in Lab., pilot plant and small volume pumping in production service.

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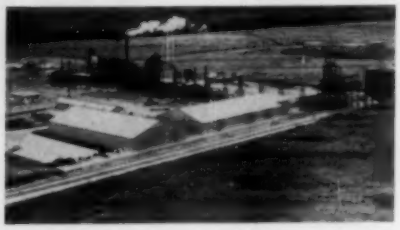
INDUSTRIAL NEWS

COLUMBIAN CARBON OPENS NEW PLANT

Contributing to the billion pound per year market of carbon black will be the 60 million pounds per year to be produced at a new carbon black producing plant of the Columbian Carbon Co. near Franklin, Louisiana. The first unit of the plant which will produce 20 million pounds per year has been recently put in operation. With completion of the entire plant toward the end of 1955, maximum output will be obtained.

Among the various types of carbon black to be manufactured will be the company's Statex 125—a new type which is finding increased use in the rubber tire industry. It is claimed to



increase the wear resistance of tire treads resulting in road mileage five times that achieved without this type of ingredient.

The processes employed in making the carbon black were developed by the company's research staff near Monroe, Louisiana. The material is collected as a light fluffy powder and then is converted to relatively dense, dust free beads.

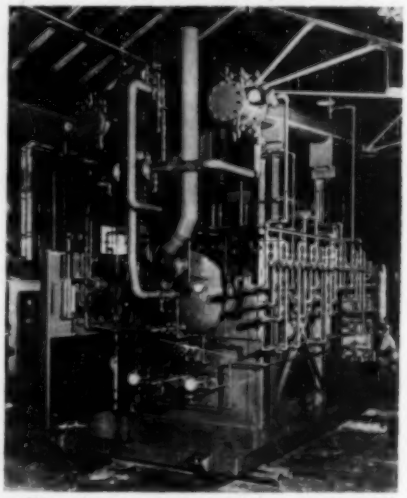
The collection system includes an electrostatic precipitator, three stages of cyclone collection and a bag filter of improved design. In the bag collector, filter bags of special silicone-treated glass fibre replace the synthetic bags previously used. The glass cloth, permitting filters to operate at higher temperatures and minimizing corrosion problems, has proved its value in full scale installations at other plants of the company.

DU PONT ANNOUNCES PLANT SITE

Du Pont has selected a plant site near Antioch, Calif., for the manufacture of tetraethyl lead and "Freon" refrigerants.

Construction will begin this summer. The plant will serve West Coast petroleum, air-conditioning, refrigeration and aerosol industries.

GIRDLER BUILDS HYDROGEN SULFIDE UNIT



The direct reaction of hydrogen with liquid sulfur to produce H_2S is now being carried on at the Sherritt Gordon Mines Ltd., Fort Saskatchewan, Alberta, Canada, by this generator shown in the shops of the Girdler Co., Louisville, Ky. The unit which supplies 3000 lbs./day of hydrogen sulfide is part of a nickel ore leaching process plant in which H_2S is needed to precipitate by-product copper and cobalt.

BOSTON ONE-DAY MEETING

March 30. Symposium on Engineers in Management. Contact W. A. Rousseau, Badger Mfg. Co., 230 Bent St., Cambridge, Mass.

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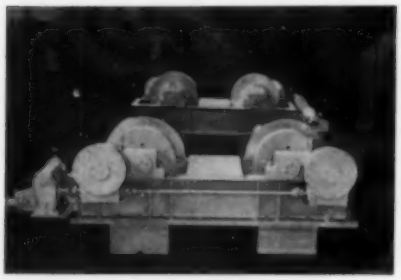
NEW 200-TON CAPACITY TURNING ROLLS

The minimization of floor space requirements was a motivating influence in the design of the new 200-ton capacity turning rolls now being produced



by the Worthington Corp. The model is ideal for use with rotating vessels having many protuberances since only one power and one idler unit is needed to handle a full 200-ton load.

In the unit the roller facings are only 7", thus assuring accessibility to almost any type of tank. The power unit is driven by a 5 HP electronic variable speed drive, offering a range of rotation speeds from 3½ to 56 in./min. Rollers are forged with the contact surfaces flame-hardened to reduce wear.

GEON PLASTIC PROTECTS AGAINST CORROSION

Capillary tubing, used to transmit pneumatic signals between process instruments, is being protected against corrosion by coating with Geon vinyl plastic. The plastic, manufactured by the B. F. Goodrich Co., safely resists most acids, alkalies, salts, and oils. It is flexible, has excellent physical properties, withstands temperatures as high as 200° F. and provides good electrical insulation.

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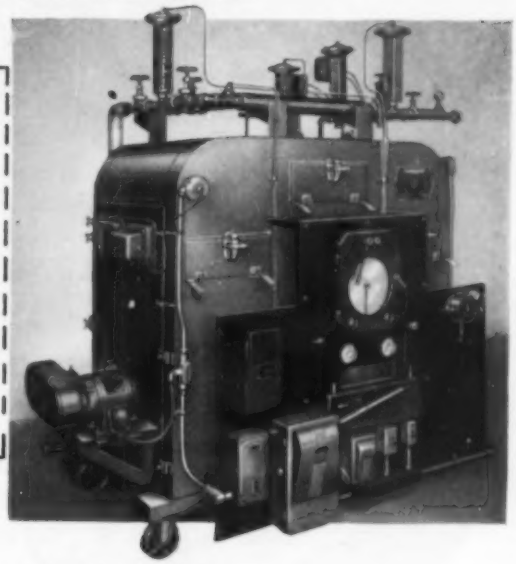

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Fertilizers
Fruits and Berries
Inks and Pigments
Metal Parts
Nuts
Paints
Paper and Paper Products
Plastics
Rubber — reclaimed, Synthetic, Natural
Textiles — fibres, yarn, cloth
Tobacco
Vegetables
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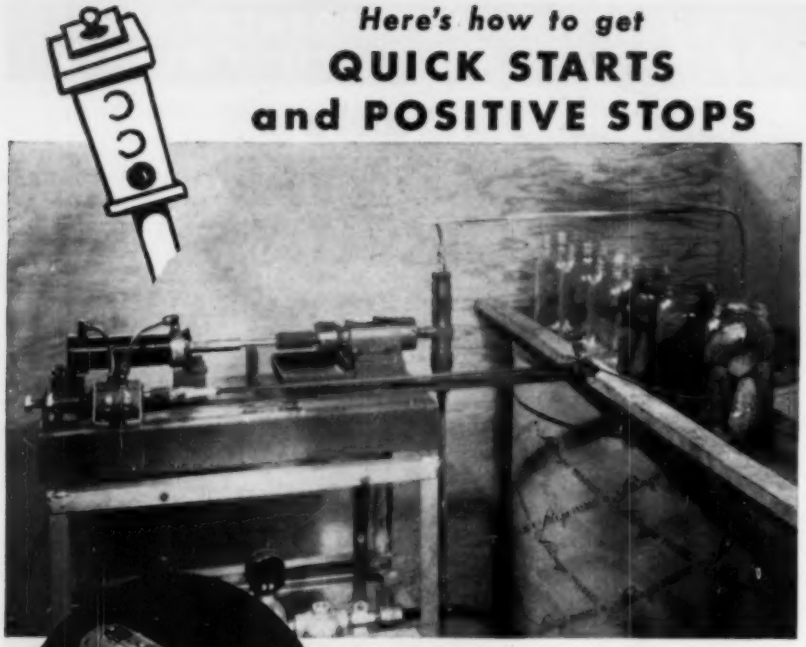
CHARLOTTE, N.C. — W. S. Anderson, Carolina Specialty Co.
PHILADELPHIA 19 — F. E. Wasson, 519 Murdock Road
TORONTO, CANADA — Hugh Williams, 47 Colburn Street



Here's how to get
QUICK STARTS and POSITIVE STOPS

New HILLS-McCANNA *AIR ACTUATED* Metering and Proportioning Pumps

Have *you* a problem involving continuous metering of small volume flows? The new Hills-McCanna air actuated pumps can solve these problems in many cases where conventional pumps are not satisfactory . . . because they have an air cylinder drive. With them you can start fast and accurately and stop immediately — at high or low speeds.

In the photo above a "UP" type pump is used as a "pickle pump" — adding just the right amount of brine to pickle jars. Other uses range from the injection of petroleum additives to putting ink in fountain pens. In all these services, the "UP" is dependable and accurate and may be used with a wide variety of controls.

Hills-McCanna air actuated pumps are available in capacities of 0.1 gph. to 200 gph., with adjustable stroke lengths for positive volume control . . . all are built to the same high engineering standards as Hills-McCanna electrically driven pumps.

Write for Bulletin UP-55 — HILLS-McCANNA CO., 2438 W. Nelson St., Chicago 18, Illinois.

DESIGN DETAILS

- External, interchangeable check valves
- Interchangeable barrel and housing
- Unitized construction, common base
- Positive stroke adjustment
- Trouble-free operation

HILLS-McCANNA

metering and proportioning pumps

Also Manufacturers of:
SAUNDERS TYPE DIAPHRAGM VALVES
FORCE FEED LUBRICATORS • MAGNESIUM SAND ALLOY CASTINGS

BEAUMONT

ONE-DAY MEETING

(*Continued from page* 36)

Connelly, Eastman) like other plastics, need to be pre-tested under service conditions using technical grades.

Liquids boiling inside vertical tubes under natural circulation present heat transfer coefficient calculation problems more easily solved by equations by V. A. Klein (Dow). These are a function of heat flux and physical properties of the system. It is not necessary to know or estimate the liquid flow rate.

R. V. Andrews, V. A. Klein, E. B. Yelton, Jr., & G. A. Filak.

Men who planned & directed the meeting; *Front:* H. A. Young (meeting vice-chairman), O. J. Gibbs (arrangements chairman), & J. Sabot (registration chairman). *Rear:* C. E. Huckaba (meeting chairman), W. E. Norris (treasurer), J. H. Lee (publicity chairman), & J. E. Sampson (program chairman).

Vacuum flash vaporization of heavy petroleum fractions at low pressures increases the yield of charge stocks to catalytic refining units, and reduces the volume of less valuable residual fuels. Filak, Sandlin & Stockholm (Magnolia Petroleum) compared plant results with four standard methods of estimating the quantity of materials vaporized. The degrees of deviation from practice were shown.

Cycloalkanone Peroxides have been made by autocatylized liquid phase reaction between oxygen and cyclohexanol and between oxygen and cyclopentanol—the product of the latter being almost as stable as that of the former—with neither being explosively unstable, according to M. J. Hartig & N. Brown (Du Pont).

Oil extenders for *synthetic rubber* are growing in use, and are improving the overall chemical characteristics although their action is not yet fundamentally understood, according to H. B. Richmond, Jr. (U. S. Rubber).

—E. E. Wagner & Jack Wright
Pictures by N. J. Vaglica

INDUSTRIAL NEWS

DURIRON PURCHASES ENZINGER UNION CORP.

The Duriron Company, Inc., Dayton, Ohio, has purchased the assets of the Enzinger Union Corporation, Angola, New York. Enzinger's plant at Angola will operate as the Enzinger Division of Duriron. It will continue with the production of stainless steel filters, multitube heat exchangers, and special equipment fabricated with stainless steel. The products of the Enzinger Division will be marketed by the Duriron sales staff.

BLAW-KNOX OFFERS REFORMING PROCESSES

Processes for the production of hydrogen from natural gas or propane, and for the conversion of gaseous or liquid petroleum materials to a mixture of ethylene, propylene and other products are now being offered by the Blaw-Knox Co. under licensing agreements with Hercules Powder Co.

For the production of hydrogen, natural gas or propane mixed with steam is passed through a catalyst in alloy tubes set vertically in furnaces operating at high temperatures, and reformed to a mixture of carbon monoxide and hydrogen. This mixture is processed through a shift converter to produce carbon dioxide and hydrogen. Recent improvements in this method make feasible the production of hydrogen from liquid petroleum fractions.

The olefins process has been tested in a full scale pilot plant installation which has demonstrated the feasibility and flexibility of the process. Separation of the olefins can be achieved through either cryogenic or absorption processes.

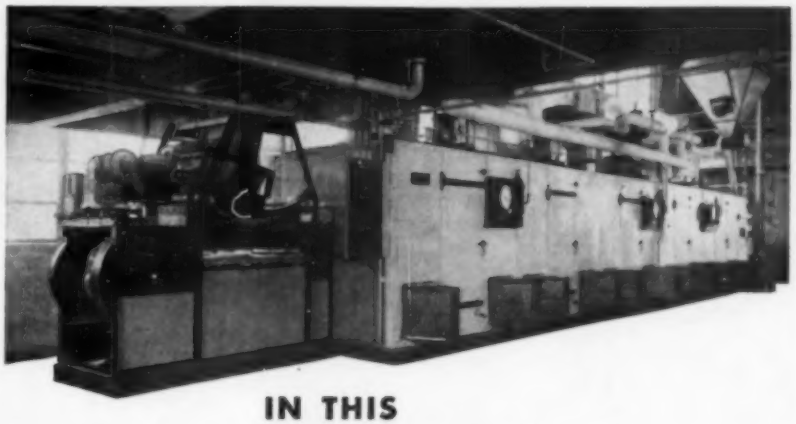
NORTON PLANS REFRACTORY PLANT

A new plant for the production of fused magnesia, fused zirconia, boron carbide and other special refractory products will be built in Huntsville, Ala., by the Norton Co., of Worcester, Mass. The plant which will cost about $1,250,000 and will add materially to Norton's electric furnace capacity. Completion of the project is scheduled for late 1955.

The plant will consist of two electric furnace buildings, an office and utility building, and a research building. They will employ about 100 people at the start.

Decentralization of the company's vital electric furnace facilities and elimination of duties on these electric furnace products, presently imported from their Canadian plant, are reasons behind the company's expansion plans.

Picture YOUR PRODUCT



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To improve your product call on Proctor & Schwartz, Inc., who not only manufacture drying equipment, but have the know-how to help you in materials handling problems which arise both in feeding the dryer and delivering your product to subsequent processing equipment.

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☐ HAVE YOUR ENGINEER CONTACT US.

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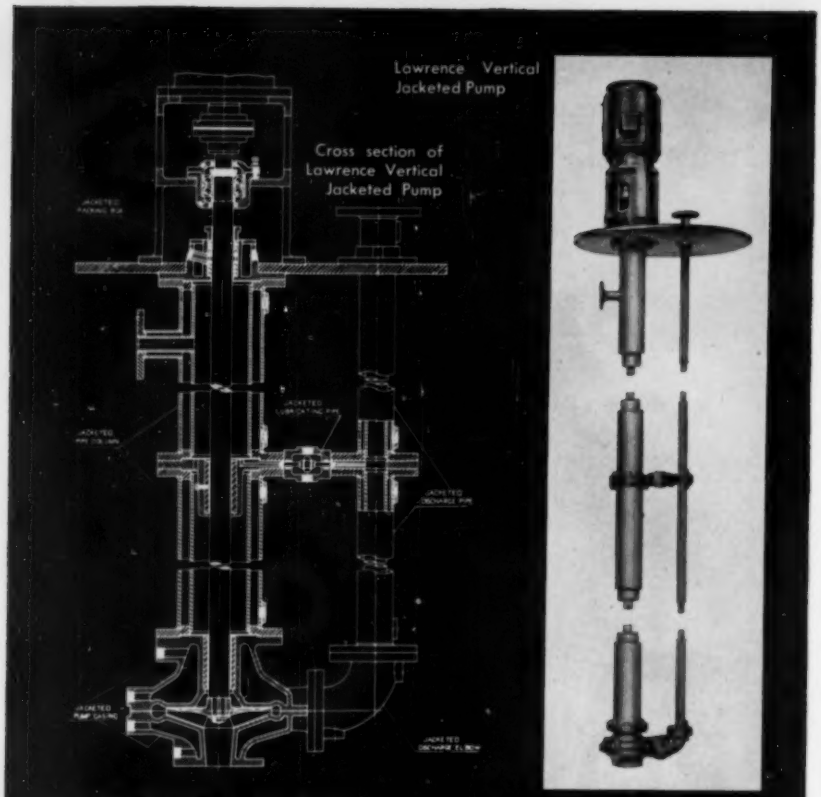
COMPANY_____

STREET_____ CITY_____ STATE_____



VERTICAL

jacketed PUMPS

Lawrence vertical jacketed pumps are designed to pump liquids such as sulphur, phthalic anhydride, resins, waxes, etc., which tend to solidify or become viscous at low temperatures. The heating medium can be steam, dowtherm, etc.

The pump is jacketed throughout, i.e. — the pump casing, pipe column, discharge pipe and packing box. All heating spaces are vented and self-draining.

For submerged operation, these pumps are frequently made with only the pipe column, discharge pipe and packing box jacketed; the pump itself, not being jacketed.

If you have to pump liquids which must be maintained above a certain temperature to prevent solidification, write us the pertinent details. No obligation.

Write for Bulletin 203-7.

LAWRENCE PUMPS INC.
371 Market Street, Lawrence, Mass.

INDUSTRIAL NEWS

LOAD CELLS AID LIQUID BLENDING

The formulation of a product by dialing in the desired amount of ingredients is being done by the aid of load-cells in the new Kralastic manufacturing plant of the Naugatuck Chemical Division of the U. S. Rubber Co. in Baton Rouge, La. With the aid of a diagrammatically laid out control panel and load cells placed under storage, mixing and weighing tanks, an operator merely pushes buttons located on the control panel and watches the operation proceed by means of lights and signalling devices laid out before him.

In the Naugatuck blending operation, resin latices and other liquids are automatically taken from storage tanks, weighed out in prescribed quantities, mixed and discharged from the system. The cycle of operations is so sequenced and interlocked that after the operator selects his weights by dialing on silhouettes located on the control panel, no mistakes can be made.

Load cells are located under four tanks, three per tank, in which mixing by agitators as well as weighing takes place. While one of the weigh-mix tanks is being filled, one may be emptying, and another being cleaned and scrubbed down. This makes the process virtually continuous. Three of the tanks have a ten-ton capacity while another has a capacity of one ton.

The blending system was designed by the Richardson Scale Co., Clifton, N. J.

UNION CARBIDE TO ADVISE ON ITALIAN RUBBER PLANT

Union Carbide will furnish consulting and management assistance to Azienda Nazionale Idrogenazione Combustibili of Italy for the design, planning, construction and initial operation of an Italian synthetic rubber plant. The new plant will be built in Ravenna, Italy, at a cost of $75,000,000 and will supply butadiene for the production of 30,000 tons annually of GR-S type synthetic rubber from natural gas.

INDUSTRIAL NEWS

PERKIN-ELMER BUYS GERMAN INSTRUMENT PLANT

Perkin-Elmer, manufacturer of electro-optical instrumentation, has announced the purchase of Bodenseewerk in Uberlingen, Germany. The plant which employs over 200 people produces cameras, theodolites, sound recorders, and high precision aircraft instruments and testing apparatus.

DIAMOND ALKALI PLANS RADIATION LAB

The harnessing of gamma rays for the investigation of chemical reactions such as polymerization, oxidation and chlorination will be carried on in a new radiation research laboratory to be built by the Diamond Alkali Co. at its research center in Painesville, Ohio. A 1,000-curie radioactive cobalt source obtained from the AEC's Brookhaven National Laboratory will be the primary gamma ray source with tracer quantities of other radioactive elements also planned for use.

The laboratory is a segment of a program of investigating the peacetime applications of atomic energy. Since 1953, the company has been the chemical partner of Foster-Wheeler Corporation, N. Y., and Pioneer Service & Engineering Company, Chicago, which are participating in the AEC's nuclear reactor development program.

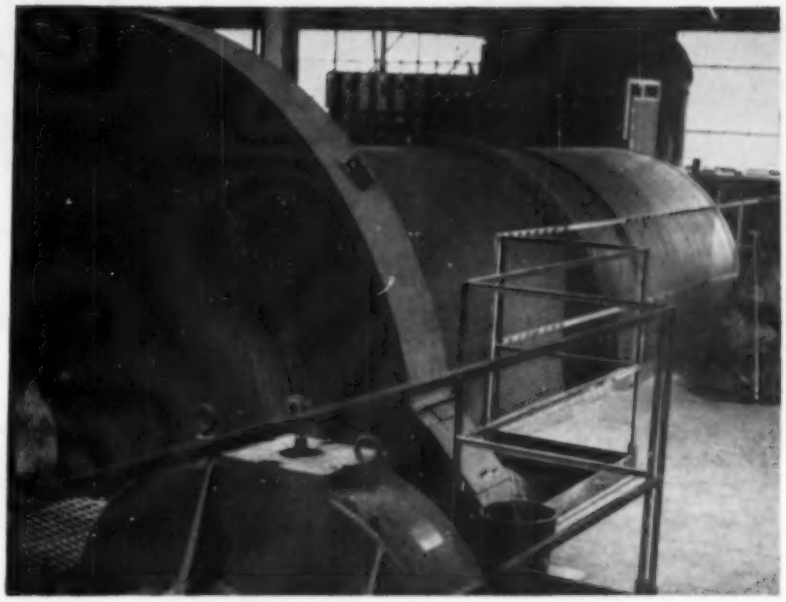
CANADA GAINS SULFURIC PLANT

A 100 ton/day sulfuric acid plant is being built in Fort Saskatchewan, Alberta for the Inland Chemicals Canada Ltd. by the Lummus Company, Canada Ltd. Construction of this new $1,000,000 plant was started in December.

The plant will market the finished product to its next-door neighbor, the Sherritt-Gordon Mines Ltd. and other industrial users in Western Canada. Pure sulfur, produced at the natural gas treating plant of Shell Company Canada Ltd. in Alberta, will be used as feed stock.

AIR REDUCTION BUILDS MONOMER PLANT

A vinyl acetate monomer plant with a 30,000,000 lb./yr. capacity will be built for Air Reduction Company by the Lummus Company. The plant will be built in Calvert City, Kentucky, and is scheduled for completion in early 1956.



Hardinge 9′ x 22′ Pebble Tube Mill in an Ohio plant producing silica flour.

Hardinge TUBE MILLS...

...for wet grinding

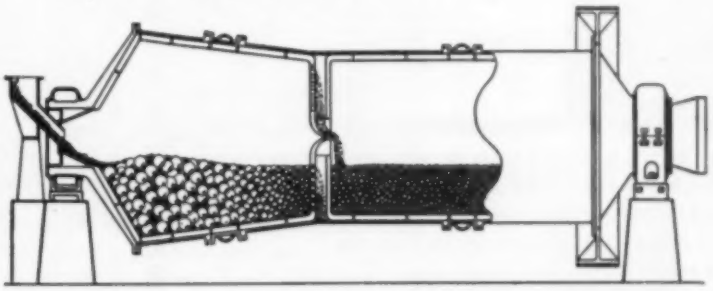
(in water or acid pulps)

Titanium Pigments
Manganese Dioxide
Diatomaceous Earth
Limestone

...for *dry* grinding

Fillers
Silica Flour
Gypsum
Carbon Black
Pigments
Cement materials

Regardless of the requirements, Hardinge Tube Mills are designed to meet specific needs. Available from 2 to 10 feet in diameter; 6 to 35 feet in length; single or multiple compartments; with acid proof lining of rubber, silica and porcelain. Complete specifications on request. Bulletin 18-B-40



Tricone compartment Tube Mill with grate and lifters.

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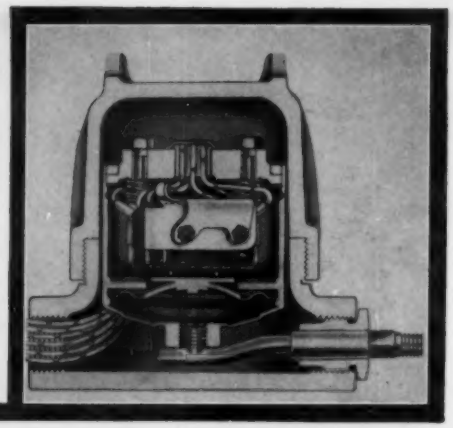

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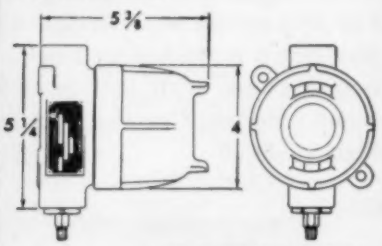
- **NOT AFFECTED BY VIBRATION** *no liquid switching elements are used*
- **RUGGED and WEATHER RESISTANT** *enclosed in a crouse-hinds case*
- **EASILY ADJUSTABLE** *by convenient adjusting nut*
- **OPERATES IN ANY POSITION** *saves installation time*

ACTUAL SIZE



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CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members will receive careful consideration if received before April 15, 1955, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Andrews, David B., *Westfield, N. J.*
Beyer, Gerhard H., *Ames, Iowa*
Carroll, Eades H., *Radford, Va.*
Crawford, Douglas W., *Aiken, S. C.*
Forbath, Thomas P., *New York, N. Y.*
Gerster, Jack A., *Newark, Del.*
Graae, Johan E. A., *New York, N. Y.*
Grad, Martin, *Cincinnati, Ohio*
Griffin, Edward L., Jr., *Glenside, Pa.*
Hatton, Robert B., *Andover, Mass.*
Hogge, A. C., Jr., *Wood River, Ill.*
Koester, Hugo A., *Munster, Ind.*
Lawrence, Sigmund J., *Schenectady, N. Y.*
Lewis, Sidney A., *New York, N. Y.*
Lifland, Philip P., *Woodbury, N. J.*
Littlejohn, Charles E., *Clemson, S. C.*
Margolis, Asher J., *Chicago, Ill.*
Martz, R. J., *Deer Park, Tex.*
McClintock, John H., *Baytown, Tex.*
Mellecker, John B., *Springdale, Conn.*
Miller, J. Paul, *Danville, Ill.*
Moore, Ward F., *Buffalo, N. Y.*
Nellums, Robert O., *Kirkwood, Mo.*
Obrecht, Robert P., *Richmond, Calif.*
Oglesby, George R., *Army Chemical Center, Md.*
Phillips, Kenneth A., *East St. Louis, Ill.*
Secord, Robert N., *North Reading, Mass.*
Smutz, Morton, *Ames, Iowa*
Steinmetz, V. A., *New York, N. Y.*
Vogel, G. J., *Oak Ridge, Tenn.*
Wilson, Glenn W., Jr., *Baytown, Tex.*
Wong, S. Y., *Austin, Tex.*
Yagi, Sakae, *Tokyo, Japan*
Zieminski, S. A., *Orono, Me.*
Zimmerman, O. T., *Durham, N. H.*

Associate

Backensto, E. B., *Woodbury, N. J.*
Banner, William E., *El Paso, Tex.*
Beck, Henry C., *Swarthmore, Pa.*
Brown, Byron T., *Phillips, Tex.*
Campbell, Keith S., *Cleveland Heights, Ohio*
Casper, Arthur, *Spring Valley, N. Y.*
Deaton, Irving F., *Western Springs, Ill.*
Detweiler, W. Kenneth, *Charleston, W. Va.*
Emery, Robert, *Maplewood, N. J.*
Friedlander, Sheldon Kay, *New York, N. Y.*
Glotzer, Herman L., *Wilmington, Del.*
Grimm, James H., *Wenonah, N. J.*
Haberstroh, William H., *Midland, Mich.*
Hogan, E. Ross, *Grand Island, N. Y.*
Hopper, Jack, *Pasadena, Tex.*

(Continued on page 74)

CHEMICAL ENGINEER HEADS UNIVERSITY

Clifford C. Furnas was inaugurated Chancellor of the University of Buffalo. This event is particularly noteworthy as it appears to be the first time that a chemical engineer has been accorded this honor.

In his acceptance address, Dr. Furnas stated his belief that there is dawning an age of almost universal college education . . . and that by 1970 most American universities will have to double in size to accommodate the increased numbers of students.

Financial assistance from industry will be the best route for obtaining the necessary funds to make possible this expansion and maintain the numbers of students enrolled, believes Dr. Furnas.

INDUSTRIAL NEWS

DOW BUYS CHELATE FIRM

The Dow Chemical Company has added chelating agents to its list of marketed products by purchasing all outstanding stock of Versenes, Inc., Framingham, Mass.

Chelating agents which are used in many of the chemical process industries have the ability to selectively inactivate or combine with various metal ions. Versene T, one of the specialties, is used in cotton textile processing to prevent iron staining. It functions in all strong caustic solutions and prevents the deposition of iron from cleaning or processing solutions. Versene Fe 3 and the regular Versene are widely used in textile dyeing operations to inactivate foreign metals allowing quicker dyeing.

These products are stable in hot and cold alkaline solutions and are important ingredients of many soaps, preventing them from becoming rancid or discolored during storage and functioning as water conditioners.

QUAKER STATE STARTS 2 PLATFORMERS

Two new UOP Platforming units have been put on-stream by the Quaker State Oil Refining Co. The Platformers, identical in design and each with a capacity of 850 bbl./day are located at the company's refineries at St. Marys, W. Va. and Emlenton, Pa.

Each unit is processing a full boiling range Pennsylvania straight run gasoline which is low in naphthene content, and is equipped with recycle gas scrubbing facilities for the removal of hydrogen sulfide.

At St. Marys 95 leaded octane is being produced with Emlenton producing 97 leaded octane material. The products from these units are used as blending stocks to produce Quaker State's Sterling brand of gasolines.

Universal Oil Products Company designed, engineered and licensed each of the Platforming units. The construction company was Procon Inc.

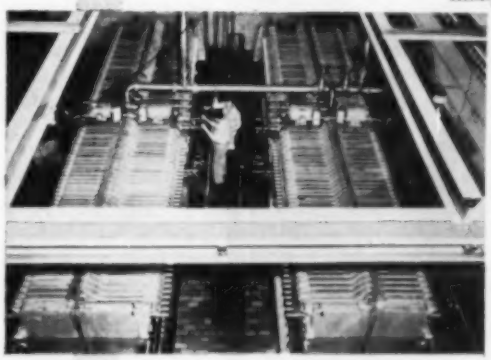
NEW SOURCE FOR ADIPIC ACID

A second major supplier of adipic acid had appeared on the market with the announcement by Monsanto that this resin is now available from them in commercial quantities.

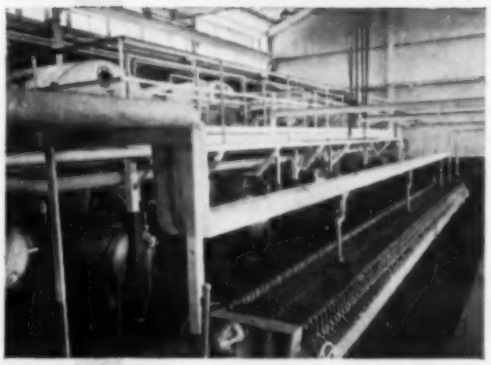
Adipic acid is being used as a raw material for nylon production, for imparting flexibility to films and polyester resins, and for modifying surface coating resins. It is also used as a chemical intermediate for the synthesis of many organic compounds.

Filter Presses Offer Many Variations to Improve Processing

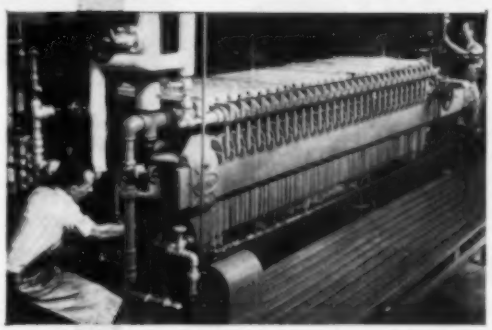
With Shriver filter presses it isn't a matter of just cake recovery or clarification. There are many operations that can be performed in a filter press or in some variation of the filter press design. Here are but three of many examples worth investigating.



These are Shriver brewery mash filters, each double-sectioned, with 40 chambers per section, which can be operated independently. Uniform, thorough extraction of the mash this way saves time, sparge water, labor, fuel and power and improves spent grains and produces drier, sweeter, more saleable filter cake.



This is not a filter press at all but a long, multiple chamber press for cooling and molding wax and similar substances into cakes of uniform size, weight and appearance, without shrinkage.



For versatility this steam heated Shriver Filter Press does about everything—filters, washes the cake, extracts all liquid, and melts the cake, all with the turn of a few valves.

There are many applications for Shriver Equipment in its multiplicity of designs, for cutting operating costs and producing better quality. The Shriver catalog tells how. Get a copy.

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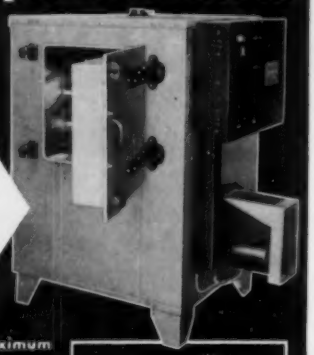

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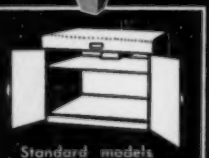

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REMPE COMPANY

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CANDIDATES

(Continued from page 72)

Jacobi, William M., *Liverpool, N. Y.*
Jenkins, J. H., *Gibbstown, N. J.*
Kase, Donald W., *St. Louis, Mich.*
Kleinfelder, Earl O., *Wilmington, Del.*
Krane, Herbert G., *Hammond, Ind.*
Krieger, Kenneth H., *Rahway, N. J.*
Laird, Richard H., Jr., *Orange, Tex.*
Luhks, Alfred J., Jr., *Roselle, N. J.*
Maag, Gustav A., *Covington, Ky.*
Magnusson, Leonard W., Jr., *Oak Ridge, Tenn.*
Mazmanian, Joseph, *Philadelphia, Pa.*
McKay, Harlan W., *Houston, Tex.*
McLain, Howard A., *West Lafayette, Ind.*
Meyer, Richard J., *Horseheads, N. Y.*
Orcutt, John C., *Broomall, Pa.*
Paules, Robert R., *Clarksboro, N. J.*
Perkins, Haywood Armstrong, *Beaumont, Tex.*
Pullen, Fletcher W., *Milwaukee, Wis.*
Reig, Fred L., Jr., *Stanton, Del.*
Rudershausen, Charles G. J., *Gibbstown, N. J.*
Saia, Joseph J., *Woodbury, N. J.*
Shea, Howard W., *Mount Royal, N. J.*
Shipman, C. William, *Newark, Del.*
Simpson, Theodore B., *Niagara Falls, N. Y.*
Stover, William A., *Pitman, N. J.*
Thorsten, Carl A., *Niagara Falls, N. Y.*
Toplitsky, Irving, *Brooklyn, N. Y.*
Umholtz, Charles L., *Baytown, Tex.*
Von Dreusche, Charles F., Jr., *Cresskill, N. J.*
Wales, Charles E., *Detroit, Mich.*
White, Lawrence E., *Mantua, N. J.*
Winters, Arthur R., *St. Louis, Mo.*
Zuehlke, James R., *Faribault, Minn.*

Affiliate

Hopkins, Robert D., *Baltimore, Md.*
Moore, Berkley L., *Pittsburgh, Pa.*
Root, A. C., *Midland, Mich.*
Timanus, W. Raymond, *Baltimore, Md.*

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INDUSTRIAL NEWS

CONOCO SHIFTS SALES OFFICES

Greatly expanding petrochemical sales operations has necessitated the shift of Continental Oil Company's petrochemical sales department to new and larger office space in New York's International Building, 630 Fifth Ave. CONOCO formerly maintained this sales staff in the RCA Building.

MEMPHIS AMMONIA DISTRIBUTION CENTER

A 5,000,000 gal. (12,000 ton) storage system for anhydrous ammonia, and what is said to be the nation's first river-rail-highway distribution facility, have been placed in operation by Mid-South Chemical Co., Memphis, Tenn.

The heart of the set-up is an eight-acre distribution center on Presidents Island, an industrial area off the Memphis river-front with harbor facilities for Mississippi River transportation as well as rail and truck loading docks.

Plans call for having the center in full operation by the peak of the 1955 fertilizer season.

DUPONT EXPANDS CHAMBERS WORKS

Additional facilities for the manufacture of polyisocyanates have been planned for Du Pont Company's Chambers Works in Deepwater Point, N. J.

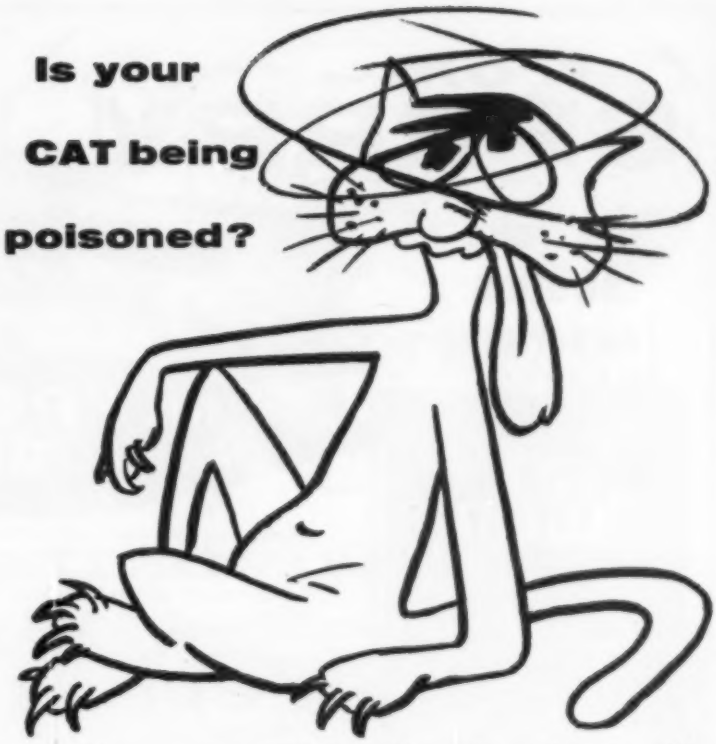
All design and construction work will be conducted by Du Pont's engineering department. Completion of the project is scheduled for mid-1956.

Polyisocyanates have been put to commercial use in the manufacture of special elastomer-based adhesives for cementing fabrics to rubber. These versatile chemicals have been reacted with other compounds to produce a wide variety of solid and cellular products ranging from hard and tough to soft and plastic.

New products developed by DuPont in the course of research on these materials have possible applications as structural panels and insulation in the form of semi-rigid or rigid foamed materials. Urethane rubber which possesses remarkable abrasion resistance is another one of the experimental products which may someday enjoy commercial success.

NEW NAME GIVEN ESSO RESEARCH AFFILIATE

Standard Oil Development Co., affiliate of Standard Oil Co. responsible for petroleum research and engineering in this country and abroad, has changed its name to Esso Research and Engineering Co.



It's easy to keep "CAT" cracking units purring . . . with Yorkmesh Demisters in your charge preparation equipment guarding the quality of your gas oil. Separation efficiencies exceeding 99.9%, with corresponding reductions in contaminating impurities and carbon content are assured even at high vapor velocities and with negligible pressure drop.

Yorkmesh Demisters are tailor-made for quick installation in new or existing equipment. On receipt of operating data and equipment arrangement, York engineers will make specific recommendations as to the size, type and material of the demister needed to improve the performance and increase the throughput capacity of any process vessel handling both liquid and vapor phase materials.

For specific details on reducing catalyst poisoning write for case study #1002 . . . for the complete story on Yorkmesh Demisters ask for bulletin #16.

Simple as spelling C-A-T

Contaminated with fine liquid droplets the vapor rises through the tower.

As the vapor stream passes through the fine wire mesh, the droplets impinge on the wire surfaces, coalesce into large drops and fall off.

The vapor is now dry and free from impurities.

Yorkmesh Demisters provide clean separation between liquid and vapor in:

Vacuum towers • Distillation Equipment
Gas Absorbers • Scrubbers • Evaporators
Knock-Out Drums • Steam Drums

YORK

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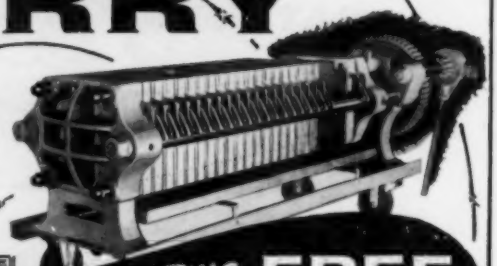
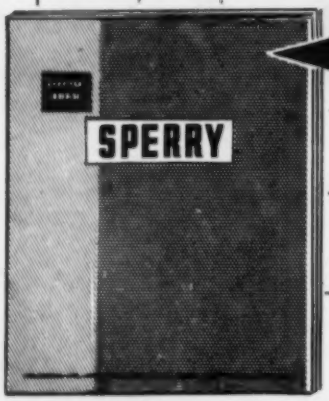
SPERRY

"the voice of filtration experience"





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N. Y. Meeting Papers Reviewed

PULSED COLUMN DESIGNS

In cases where an organic liquid is dispersed in water, the wetting quality of perforated plate surfaces makes little difference as far as the operation of the extractor is concerned. When, however, water is dispersed in the organic liquid, this wetting quality causes irregular performance—which is probably the reason why little use has been made of these columns for such applications. To correct this problem, the authors propose either selecting for the plates a material with suitable surface-wetting characteristics, or coating of the surface of existing plates with a suitable compound that will do the same.—*"Perforated plate extraction column performance and wetting characteristics." by F. H. Garner, S. R. M. Ellis & J. W. Hill, The University, Birmingham, England.*

FILTER MEDIA—ART BECOMING A SCIENCE?

The evaluation of filter media in the past has been largely through trial and error. Over 500 commercial media have been found useful in filtration of liquids. Now, out of the DuPont Engineering Research Laboratory come two important studies. A so-called "mercury-intrusion" method is used to determine pore size. Then a second procedure, which involves a controlled clarification operation, has given results that may ultimately lead to the prediction of filter media performance on the basis of pore structure. *"Structure and performance of filter media; Parts I & II." by H. P. Grace, DuPont*

PREDICTING EXTRACTOR PERFORMANCE

A study was undertaken to determine the effect of several variables on the efficiency of agitated extractors and to confirm if possible the published procedures for predicting continuous flow performance from batch tests. The authors found that the degree of baffling required to produce fully baffled operation in an agitated vessel is greater when the vessel is full than when partially full; that extraction efficiency attributable to agitation is a function of agitator energy input per unit volume of total liquid flowing; and that it is possible to predict the performance by at least one published method.—*"Liquid-liquid extraction in continuous-flow agitated extractors." by A. W. Flynn & R. E. Treybal, N. Y. University.*

CHLORINATION HYDROCARBON

A process for chlorination of hydrocarbons using byproduct HCl involving development of special catalysts is described in detail. Principle involved is the use of chlorine as the primary chlorinating agent, and employment of the byproduct HCl formed during the primary reaction in a secondary chlorination. The result is virtually complete use of the chlorine fed into the process. Instructions for catalyst preparation included. *"Utilization of byproduct HCl as a chlorinating agent." by A. J. Teller, Fenn College*

HOW ESSO IMPROVED ITS EXTRACTORS

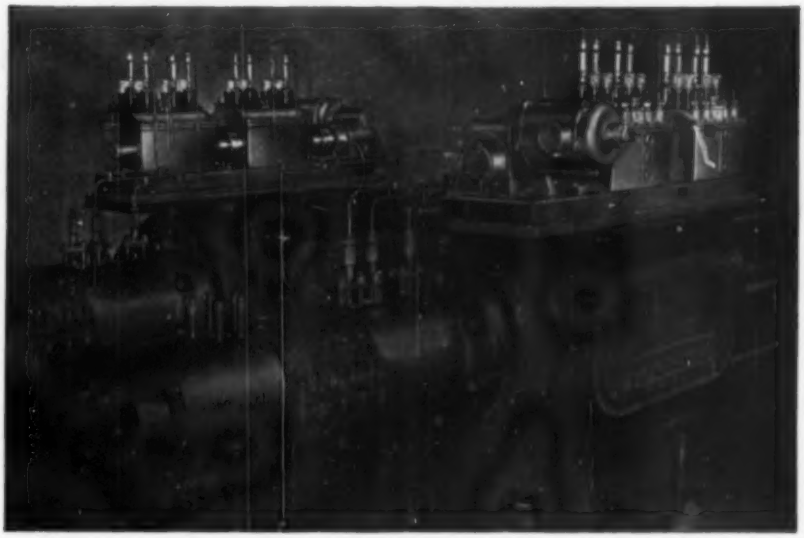
Premium grade lube oils are manufactured by affiliates of Standard Oil Co. (N.J.) by phenol extraction of stocks. Aromatics of low viscosity index dissolve preferentially in the continuous phenol phase to form an extract while paraffins and naphthenes of high v.i. are insoluble. Contacting is done in multistage, plate-type towers using countercurrent flow between stages and cocurrent flow within stages. As a result of an experimental program to improve operation of these towers, it was found that extraction temperature has a marked influence on stage efficiencies—higher temperature gives higher efficiency and permits higher flow capacities; interfacial tension, though not a major variable in lube extraction, also has a major effect on stage efficiency by affecting drop size. Entrainment reduces efficiency markedly. *"Efficiency & capacity factors in lube extraction." by J. R. Felix & C. H. Holder, Standard Oil Development Co.*

EXTRACTION OF BROTHS WITH THE PODBELNIAK

The Podbelniak Centrifugal Contactor has grown into wide use where small amounts of suspended solids are encountered. Now a newly developed model placed in initial service as late as September 1953, to handle solids contents as high as 15%, has been studied in full scale operation. Chloromycetin broth was extracted. Compared to a conventional 2-step process of filtration and extraction, these advantages are claimed for the Podbelniak: Overall yield of chloromycetin increased 10% following conversion to whole broth attraction; "out of pocket" unit cost of product lowered by 18%.—*"Commercial extraction of unfiltered chloromycetin and penicillin fermentation broths in the Podbelniak Centrifugal Contactor." by D. W. Anderson & E. F. Lau, Parke, Davis & Co.*

(Continued on page 78)

High Pressures HOLD NO TERROR FOR Manzel FORCE FEED LUBRICATORS!



Where dependable lubrication under high pressure is essential to the efficiency of such equipment as pumps and compressors, Manzel has the answer. Models are available for operation against discharge pressures of up to 30,000 P.S.I.G. Manzel thus offers the Chemical Industry the means of insuring maximum life of oil seals – and competent assistance in engineering special lubricator installations to meet specific needs. For Force Feed Lubricators — and Chemical Feeders, too, — put Manzel at the top of your list of those to call.

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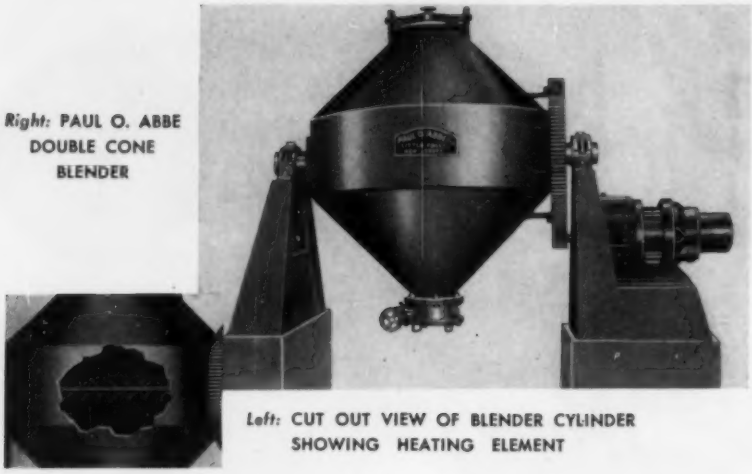

Right: PAUL O. ABBE DOUBLE CONE BLENDER

Left: CUT OUT VIEW OF BLENDER CYLINDER SHOWING HEATING ELEMENT

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PAUL O. ABBÉ CONE BLENDER

The Paul O. Abbé cone blender has proved the fastest and most thorough blender for mixing chemicals, dyestuffs, pharmaceuticals, metals, foodstuffs, and other products.

The Paul O. Abbé blender gives complete intermingling of materials. The angle of incidence and reflection because of the cone design insures complete dispersion and mixing. There is no separation of materials regardless of their number or relative weights. No other type of mixer provides this ideal mixing action.

Nor are there any dead spots. There is no possibility of an aggregate getting in one spot and failing to move away as occurs with other types of blenders. In addition this blender has high productive capacity with a minimum of floor space. Power requirements are low.

For complete details write for descriptive folder.

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INDUSTRIAL NEWS

CARBIDE PUTS NEW TEXAS PLANT INTO OPERATION

The full-scale operation of a new chemicals plant at Seadrift, Tex., for the production of ethylene oxide, polyethylene and butadiene, has been begun by the Carbide and Carbon Chemicals Co., a division of Union Carbide and Carbon Corp. Regular bulk shipments of specification grade materials are already being made.

This is the fifth Carbide plant producing ethylene oxide. The principal outlets for the product are all-winter type anti-freeze, household detergents and synthetic fibers.

The new facility will increase the industry's production of polyethylene by more than 25 per cent.

Butadiene, a constituent of synthetic rubber, is one of the other major products to be produced at Seadrift.

N. Y. Meeting Papers Reviewed

(*Continued from page 77*)

CONTROL OF FERMENTOR BY OXYGEN UPTAKE

Difficulties in scaling-up from shake flasks to tank-type geometrically-dissimilar fermentors may be alleviated through the use of a device which is keyed to oxygen absorption rate within the control unit. Stirring speed is the variable controlled in the slave unit.—*"Automatic translation of aeration data between different fermentors." by Ping Shu, N.R.C. of Canada.*

SOLVENT EXTRACTION OF TISSUES

Conventional methods of cooking tissues, followed by pressing to recover oils may well be replaced by solvent extraction processes—particularly like the one developed by the authors, for which is claimed: Retention of biological values in the original material; separate recovery of oils and solids (the latter in granular form, free from excessive dust); complete freedom from obnoxious odors (water removed can be disposed of without polluting streams or lakes); minimum exposure to air or to oxidizing conditions. The processing of milk may be revolutionized. A water-immiscible fat solvent is used, such as ethylene dichloride. A 10-ton plant is now being built in Norway, to be operating in 1955. *"An azeotropic process for dehydrating and defatting tissues at low temperature." by E. Levin, Viobin Corp. & R. K. Finn, U. of Illinois*

INDUSTRIAL NEWS

KOPPERS PLANS $20,000,000 EXPANSION FOR '55

Koppers Company, Inc., will spend in excess of $20,000,000 during 1955 for new plants and equipment and for expanding present facilities. Sizable proportions will go into the completion of a large plant at Port Arthur, Texas, for polyethylene production, and into the Salem, Virginia, plant of the company's Wood Preserving Division.

NEW VANTON OFFICE

Vanton Pump & Equipment Corp. has moved its executive and sales offices from the Empire State Building to its plant location in Hillside, New Jersey. The reason for the consolidation of management, sales and engineering activities is attributed to a need for closer liason and communications.

MINNEAPOLIS-HONEYWELL EXPANDS SALES FORCE

Forty-two sales engineers were recently added to the field sales force of Minneapolis-Honeywell Regulator Company's Industrial Division. The engineers are spread out over the 25 branch offices of the company. Increased complexities of marketing in the automation field influenced the sales force expansion.

ATLAS POWDER MOVES

Atlas Powder Company have moved their general offices from the Delaware Trust Building in Wilmington, Delaware, to a new building of their own 3 miles from the center of downtown Wilmington. The new building will provide additional space needed for the expanding staff.

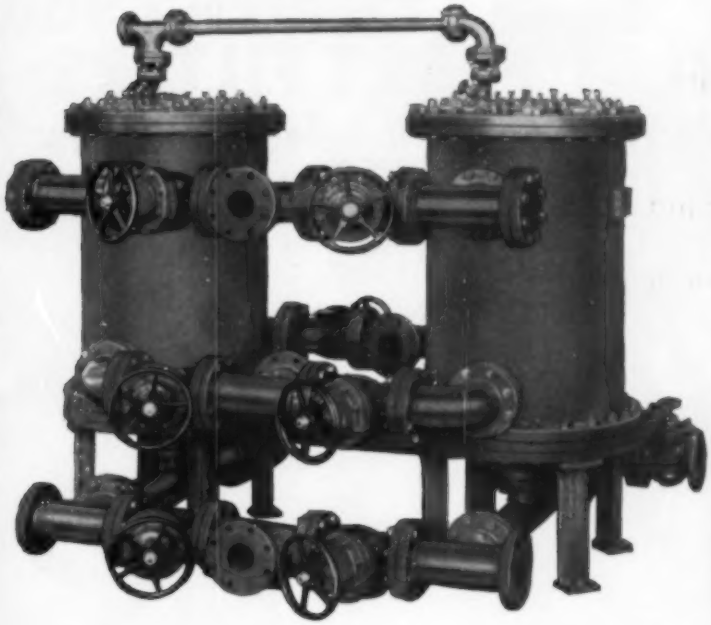
AMERICAN CYANAMID ENTERS THERMOPLASTICS

American Cyanamid Company has announced plans for the expansion of their plastics and resins division into the field of thermoplastics. Construction of a new unit at the Wallingford, Connecticut plant has been started along with construction of a unit for producing a new plastic intermediate, monomethyl styrene, at the company's Fortier Plant near New Orleans, La. It is expected that the output of the thermoplastics plant will reach forty million pounds per year.

ETHYL BUILDS CANADIAN PLANT

The first Canadian plant to produce "Ethyl" antiknock compounds will be built in Sarnia, Ontario, by the Ethyl Corporation.

here's Proof Positive



Rapid clogging of the sand in their spent brine disposal well resulted in the R. P. Adams Company being called in for consultation by an international chemical manufacturer. The two Adams CFR-5 rubber lined filters shown are similar to the first two units which successfully kept the existing well in operation . . . saved the tremendous expense of acidizing the well or drilling new ones . . . proof positive that Adams filters can save you money, even in waste disposal.

ADAMS FILTERS can SAVE YOU MONEY!

Several years ago, the R. P. Adams Company, Inc., was asked to help solve a filtering problem for one of the world's largest chemical firms. After a study of the problem, two Adams CFR-5 rubber lined filters were delivered.

RESULTS? There can be no question about results, for the two additional filters shown above were recently ordered . . . "to be identical to the two previously purchased."

If you have a filtering problem, it will pay you to find out how R. P. Adams Filters can save you money. Write today and give us full details of your problem, or ask for our Bulletin 431.

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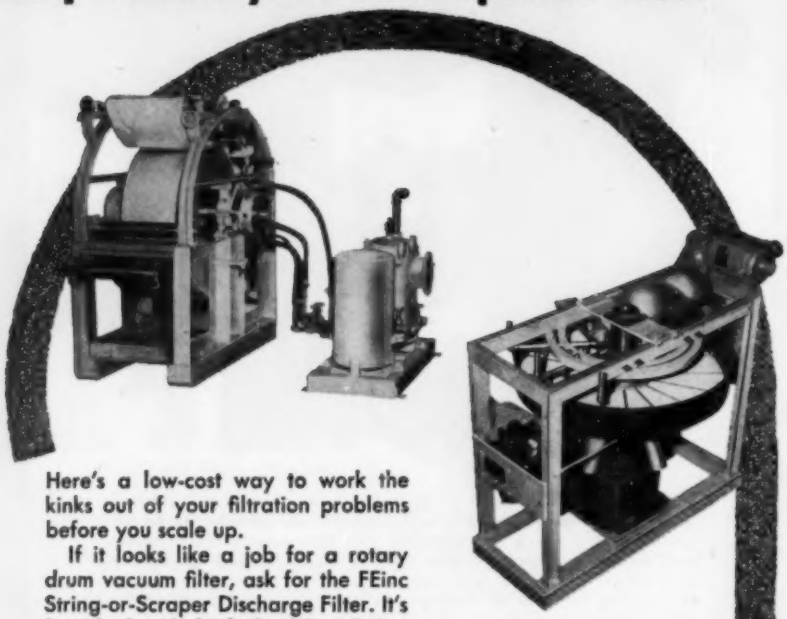
help reduce your development costs



Here's a low-cost way to work the kinks out of your filtration problems before you scale up.

If it looks like a job for a rotary drum vacuum filter, ask for the FEinc String-or-Scraper Discharge Filter. It's furnished with *both* the FEinc String Discharge and the FEinc Scraper Discharge mechanisms. You can try first one, then the other. It also has the FEinc submergence washing and compression dewatering mechanisms. These can be operated separately or disconnected if desired. This all-purpose pilot plant filter is available to you on a unique rental-purchase plan, requires no capital investment. Ask for details.

If it's a relatively free-filtering job, such as a coarse crystalline or fibrous pulp, try the simpler FEinc Horizontal Filter first. Particularly good for counter-current or multiple-stage washing. Only 3 ft. dia., with amazingly high output.

Whatever your problem, if it's *continuous* filtration, talk to FEinc first. Our engineering service is backed by 35 years of experience, and by our well-known ability to deliver filters that are tailor-made to fit the job . . . at no more than standard costs.

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News of the Field

FROM LOCAL SECTIONS

Washington, D. C. The basis for proposed sale of the synthetic rubber plants to private industry (subject to approval of Congress—expected to be forthcoming) is equitable both to industry and Government. This was the consensus of the panel of experts appearing before the February 15th meeting at the National Press Club. Panel consisted of J. P. Coe, U. S. Rubber Co.; J. T. Cox, Jr., Cox & Weinrich; J. H. Fall, Jr., Consultant; and F. M. Simpson, Petroleum Chemicals, Inc. The panel was moderated by W. J. Murphy, A.C.S.

While the changeover from Government to private operation of synthetic rubber plants is seemingly assured, the rubber problem as a whole will continue to be important to national defense as long as we are dependent upon natural rubber supplies. It seems that it is still necessary to use natural rubber in making heavy-duty truck tires. While we are stockpiling as much as we can, it cannot be stored indefinitely. Supplies in the far east are not too secure. We need to develop a synthetic that will take its place. To assure proper coordination of basic research for the next year, the National Science Foundation has been asked to assume this responsibility.

Idaho Falls, Idaho. There is a need for developing low cost methods for the recovery of fission products from wastes such as those produced at the Idaho Chemical Processing Plant according to C. E. Stoops, Phillips Petroleum Company. At a meeting of the Idaho Chemical Engineering Society on Jan. 21, in Idaho Falls, Idaho, Dr. Stoops discussed the use of high energy radiation in chemical syntheses.

Dr. Stoops reviewed much of the available information on the possible uses of radiation to promote chemical reactions and indicated the systems which seem most promising. He discussed the effect of radiation on various gas and liquid phase reactions. He pointed out that unclassified estimates of the costs of recovering waste fission products suitable for use as radiation sources, would indicate that the commercial applications are limited to those involving new reactions or producing unusual effects.

The newly elected officers of the organization which plans to apply for local section status this year are Chairman, A. L. Ayers; Vice-Chairman, D. E. Griffin; Secretary, L. Chajson; Treasurer, G. K. Cederberg; Executive Committee, J. A. Buckham, and D. M. Paige.

—L. CHAJSON

News of the Field
FROM LOCAL SECTIONS

Central Ohio. All around balance of good physical properties of Mylar polyester film has resulted in many applications to consumer products. Dr. R. L. Burton, process development supervisor of the films department at Du Pont, demonstrated some of its outstanding physical properties to a January 25 meeting of the Central Ohio Section.

According to Dr. Burton the exceptionally high tensile strength of Mylar makes it ideal for various types of tapes, for a base for metallic yarns, for covering accoustic tiles and for metallized films. Its moisture insensitivity, in addition to its tensile strength, has made possible magnetic recording tapes of exceptionally long life. High dielectric strength and homogenous structure has allowed reduction in size of electrical capacitors. Chemical inertness of Mylar has made it attractive in specialized packaging applications.

Announcement of the election of officers was made at this meeting. They are Chairman, R. B. Filbert, Jr.; Vice-Chairman, E. E. Smith; Secretary-Treasurer, J. W. Salter; Executive Committee, K. S. Jacobs, A. Syverson, D. Peterseim. —E. E. Smith

Tulsa Section. "Recent Developments in Measurement and Control" was the subject of an interesting talk given by Mr. W. H. Howe to a meeting of the Tulsa Section on January 19. Mr. Howe is Chief Engineer, The Foxboro Co., and a veteran of the measurement and control business. —J. H. Kelly

South Texas. Those elected to manage the South Texas Section for this year are Chairman, G. T. McBride, Jr.; Chairman-Elect, D. A. Smith; Secretary, J. H. Presnell; Treasurer, A. E. New; Past Chairman, J. J. McKetta, Jr.; Executive Committee, W. B. Howard, D. G. Schroeter, and C. L. Fitzgerald, Jr. —C. L. Fitzgerald, Jr.

(*Continued on page 82*)

SUPPLEMENT TO THE 1954 YEARBOOK

The 1954 Yearbook has been available to members on request since August, 1954. Since the Yearbook is published every two years a supplement containing the names of the officers and directors, committee personnel, local section officers and student chapter counselors for 1955 may be obtained by addressing your request to A.I.Ch.E. headquarters, 25 West 45th Street, New York 36, N. Y.

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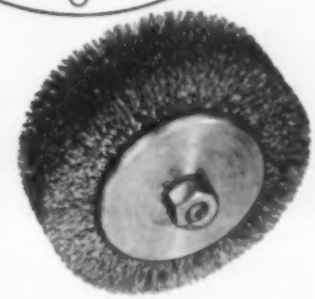

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ROTOJET Model C-525 Air-driven Motor with swing-frame head and universal joint.

ROTOJET Junior Model C434 Air-driven Motor, flexible coupling, expanding brush.

ROTOJET Model C-526 Air-driven Motor with pivot head and universal joint.

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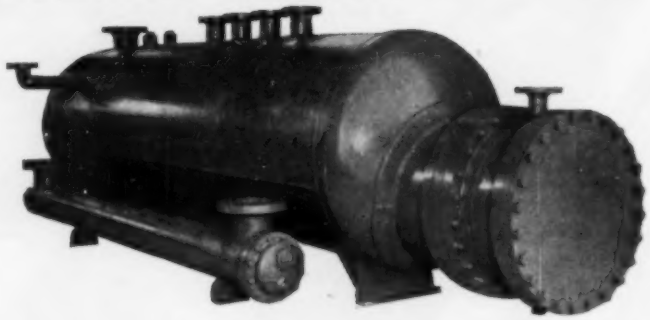

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AMMONIA 2,800 to 14,000 lb/hr
CHLORINE 10,000 to 49,000 lb/hr

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News of the Field
FROM LOCAL SECTIONS

Southern California. There is more synthetic rubber produced and consumed annually than there is natural rubber imported according to H. L. Fisher, Director of TLARGI Rubber Technology Foundation at the University of Southern California. Speaking before the January 18 meeting of the Southern California Section.

Sale of government-owned plants to private industry is progressing toward the final stages. These plants which were built at an original cost of about $750,000,000 are apparently going to be sold for about $300,000,000. According to Dr. Fisher this represents a fair value for the present plants.

—F. G. SAWYER

South Texas. The cost of exploring for oil and gas over waters of the Gulf of Mexico are running from two to five times the cost for similar operations over land, according to Mercer Parks of Humble Oil & Refining Co. Mr. Parks addressed a meeting of the Section attended by about 70. Some of the problems harassing the over-the-water explorer are: Hurricanes, waves caused by prevailing winds, fog and rain, high temperatures in steel-wall vessel equipment exposed to radiation from the sun. In the latter problem, air conditioning is used as a remedy. Major expenses are those for building platforms, and for transportation. Piling often has to be driven to 200 ft. depths. Heliocopters have proved economical for transporting personnel and small cargoes, but boats and barges are used for heavy cargo. Dualpurpose pipe lines get various products to shore.

Charleston. Titanium, still costing around $10/lb., is nevertheless promising for corrosion service in processing, according to C. I. Smith, of DuPont, speaking before an audience of 140 at the February meeting of the Charleston, W. Va. Section. Properties making titanium most useful are its strength to weight ratio (density of about 4.5), and corrosion resistance. The former is retained at a good level even at elevated temperatures in the range of 400-800° F. Corrosion resistance is exhibited to sea water, chlorine and chlorides. It is attacked under some conditions by acids such as HCl, HNO_3, and H_2SO_4. Its principal impurity, difficult to remove, is oxygen.

Virginia. New officers are Chairman, J. H. Hill; Vice-Chairman, G. W. Dean; Secretary, R. W. Nash; Treasurer, R. N. Tennyson; Executive Committee, G. J. Coli, M. E. Kalen, W. L. Stafford, and F. C. Stults.

the chemical engineer in marketing

H. Leslie Bullock, author of previous and a forthcoming C.E.P. article, is appointed district sales engineer for C. A. Litzler Co. to cover the New York and New England area. Mr. Bullock, a licensed professional engineer, has headquarters in New York City.

George F. Sharrard is manager of the technical service division of R. M. Hollingshead Corp.

At a New York dinner in his honor this month, **Kenneth R. Brown** will receive the 1955 honor award of the Commercial Chemical Development Association for his pioneering work in development and marketing of sorbitol and related prooducts. He is vice-president of Atlas Powder Co., Delaware.

Charles E. Beaver moved to position of sales manager at Research-Cottrell, Inc.

R. F. Warren appointed manager of sales, service and statistics for industrial chemical division of American Cyanamid Co. **H. P. Callahan** named technical director of manufacturing organization with headquarters in New Jersey.

Seymour Weinstein affiliates with Process Filters, Inc., as direct Chicago and mid-west sales representative.

Edgar L. Demarest heads new Buflovak division of Blaw-Knox in Philadelphia as district sales manager.

Conoflow Corp. appoints **George S. Edwards** sales representative for Cono Controls in Alabama.

Responsibility for market developmentment of aryl chemicals given **David S. Alcorn** in new position as product manager in fine chemicals division of Carbide and Carbon Chemicals Co.

Winthrop M. Barnes will guide market research as supervisor in this department of chemical division of Celanese Corp. of America.

Minnesota Mining & Manufacturing Co. names **Fred J. Wehmer** commercial development manager of adhesives and coatings division.

(*Continued on page* 84)

Quikupl
Stops costly equipment waste! Quikupl fittings can be used over and over with only occasional change of sealing ring. Inventories are cut to the bone.
Quikupl
Provides safe, leakproof connections without threading, welding or flaring! Choice of sealing ring materials for long list of corrosive solutions.
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MARKETERS

(*Continued from page* 83)

Charles E. Meginnis takes over as district sales manager in the industrial chemicals department of the Davison Chemical Company with headquarters in Chicago.

In this capacity, Mr. Meginnis will have sales and administrative responsibilities through the middle west. Before his appointment to this position, Mr. Meginnis served Davison as resident field service engineer.

B. F. Goodrich Chemical Co. names **W. D. Lahey** sales manager of extrusion and molding material and **H. L. Wuerth** sales manager of wire and cable materials. Both men are graduate chemical engineers.

Richard A. Sutherland appointed supervisor of recently formed end-use research group in Dupont's film department.

Koppers Co. appoints **George H. Sollenberger** as technical coordinator of plastics market development in the chemical division of the company.

H. E. Minnerly represents B. F. Goodrich Chemical Co. in Chicago for Hycar and rubber chemicals sales.

Herbert B. Sliger promoted to assistant export manager for Permutit Company.

Chemical engineering grad **Wallace G. Alexson** joins staff of contract sales department of M. W. Kellogg Co.

L. F. Long, Jr., takes over middle South territory as industrial sales representative for Nubian industrial division of Glidden Co.

Dr. Alvan H. Tenney named manager of market research at Carbide and Carbon Chemicals Co. to assist Dr. R. L. Bateman in surveys of future markets for new and already established chemicals.

James O. King, chemical engineering grad from the U. of Tennessee is promoted to special staff assistantship in sales department of Diamond Alkali Co.

Robert E. Barnum joins Goodyear Tire & Rubber Co.'s chemical division as field sales representative in Southeast area.

Herbert Heesch takes over as general sales supervisor of Hooker Electrochemical Co. in Niagara Falls. **John A. Fyffe** is appointed sales representative to work from New York office.

(*Continued on page* 91)

PEOPLE

Loren P. Scoville, presently a director of the A.I.Ch.E., takes over position of general manager of the chlorinated products division at Diamond Alkali Company. He replaces **C. E. Lyon** who will retire on May 1.

Mr. Scoville joined Diamond last March with experience of nearly a quarter—century in chemical process engineering and management. He earned degrees in chemical engineering from the U. of Redlands and California Institute of Technology.

Moving up as successor to Mr. Scoville as director of engineering will be **C. C. Brumbaugh,** with Diamond since 1937.

Douglas S. Calder named vice-president and general manager of Mallinckrodt Chemical Works, Ltd., in Montreal. He was also elected to the board of directors of the company.

Herman E. Bakken named general manager of the refining division of ALCOA.

Bruce A. Lister appointed lab director for product and process development for General Foods. **Harold E. Devaney** joins company as assistant technologist in the engineering research unit.

William L. Glowacki announced as assistant director of research of Eastern Gas and Fuel Assoc. in Boston.

Esso Research and Engineering Co. places **John Weikart** as section head of the hydrotreating section in the process research division of the company.

Jerome Wilkenfeld promoted by Hooker Electrochemical Co. to assistant technical superintendent in the Niagara Falls plant.

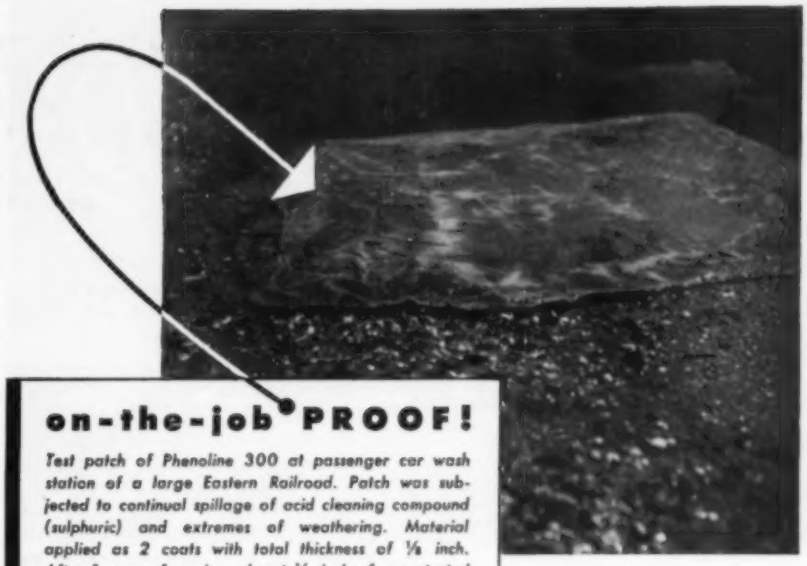
Bion D. Barger, Jr., and **John Kehm** join process study group of the company.

Morgan Jones takes over position of plant manager at the new Orange, Tex. subsidiary of Acheson Dispersed Pigments Co.

Goodyear Tire & Rubber Company promotes **L. A. Bedford** to position of manager of quality control in chemical operations department.

Replacing Bedford as section head in chemical materials development department is **F. C. Betzhold.**

(*Continued on page* 88)



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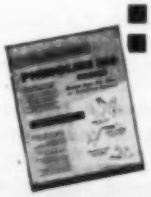

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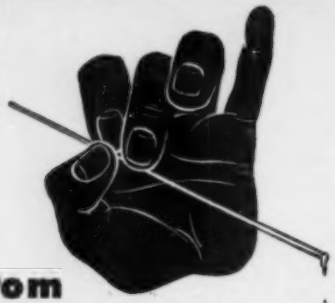

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FUTURE MEETINGS and Symposia of the Institute

Note: The Author Information column will appear quarterly in the January, April, July and October issues.

MEETINGS **SYMPOSIA**

■ HOUSTON, TEXAS

May 1-4, 1955. Shamrock Hotel.

TECHNICAL PROGRAM CHAIRMAN: J. L. Franklin, Res. Assoc., Humble Oil & Refining Co., P. O. Box 1111, Baytown, Texas.

Nucleation Processes

CHAIRMAN: D. W. Oakley, Plant Mgr., Metal & Thermit Corp., 1 Union St., Carteret, N. J.

Flow of Fluids Through Porous Media

CHAIRMAN: H. Dayton Wilde, Mgr. Res. Div., Humble Oil & Ref. Co., Box 2180, Houston 1, Tex.

Extractive and Azeotropic Distillation

CHAIRMAN: Dr. D. E. Holcomb, Dean of Eng., Texas Technological College, Lubbock, Tex.

The Chemical Engineering Curriculum

CHAIRMAN: Dr. J. W. Mason, Dean of Eng., Georgia Inst. of Tech., Atlanta, Ga.

Differences in Chemical Engineering Theory

CHAIRMAN: Dr. F. A. Landee, Dow Chemical Co,. Midland, Michigan.

Deadline Past

■ LAKE PLACID, N. Y.

Sept. 25-28, 1955. Lake Placid Club.

A meeting devoted to the problems of interest to top management.

NOTE—No general papers

TECHNICAL PROGRAM CHAIRMAN: L. J. Coulthurst, Mgr. Proc. Engr., Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

Chemical Engineering Organizations

CHAIRMAN: J. F. Thornton, Pres., The Lummus Co., 385 Madison Ave., New York 17, N. Y.

Growth of the Oil & Chemical Industry by Integration

CHAIRMAN: Mr. F. M. Simpson, Petroleum Chemicals Inc., 54 Wall St., New York 5, N. Y.

Packaged Power

CHAIRMAN: H. Arthur Martin, Exec. Vice-Pres., J. F. Pritchard Co., Kansas City, Mo.

Deadline—May 25, 1955

Atom Profits

CHAIRMAN: Dr. W. Kenneth Davis, Reactor Dev. Div., U. S. Atomic Energy Comm., 1901 Constitution Ave. N.W., Wash., D. C.

■ ANNUAL—DETROIT, MICH.

Nov. 27-30, 1955. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. J. Carron, Supervisor, Chem. Eng. Section, Ethyl Corp., Res. Labs., 1600 West Eight Mile Road, Detroit 20, Mich.

Photochemical Processes

CHAIRMAN: Prof. J. J. Martin, Dept. Chem. Eng., Univ. of Michigan, Ann Arbor, Mich.

Biochemical Engineering

CHAIRMAN: Dr. H. O. Halvorsen, Dept. of Bacteriology, Univ. of Illinois, 362 Noyes Lab. of Chem., Urbana, Illinois.

Technical Societies Cooperation with Chemical Engineering Industries

CHAIRMAN: Prof. J. B. Phillips, Dept. Chem. Eng., Phys. Sciences Centre, McGill Univ., Montreal 2, Canada.

MEETINGS **SYMPOSIA**

Mechanics of Bubbles and Drops

CHAIRMAN: Prof. R. C. Kintner, Dept. Chem. Eng., Ill. Inst. of Tech., 3300 Federal St., Chicago 16, Ill.

Deadline—July 27, 1955

■ LOS ANGELES, CALIF.

Feb. 26-29, 1956. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. Weaver, Proc. Eng., The Fluor Corp., Ltd., Box 7030, East L. A. Station, Los Angeles 22, Calif.

Deadline—Oct. 26, 1955

■ NEW ORLEANS, LA.

May 6-9, 1956

TECHNICAL PROGRAM CHAIRMAN: H. E. O'Connell, Assoc. Dir. Process Div., Sect., Ethyl Corp., Box 341, Baton Rouge, La.

■ PITTSBURGH, PA.

Sept. 9-12, 1956

TECHNICAL PROGRAM CHAIRMAN: Carl C. Monrad, Carnegie Institute of Technology, Pittsburgh, Pa.

■ ANNUAL—BOSTON, MASS.

Dec. 9-12, 1956. Hotel Statler.

TECHNICAL PROGRAM CHAIRMAN: W. C. Rousseau, Proc. & Sales Eng., Badger Mfg. Co., 230 Bent St., Cambridge 41, Mass.

Deadline—August 9, 1956

UNSCHEDULED SYMPOSIA

Extraction of Hydrocarbons for Chemical Use from Pipeline Gases

CHAIRMAN: E. E. Frye, J. F. Pritchard & Co., 210 W. 10th, Kansas City 5, Mo.

Fundamental Mechanisms in Boiling Cavitation and Condensation

CHAIRMAN: R. R. Hughes, Shell Development Co., Emeryville, Calif.

■ PHILADELPHIA, PA.

April 26, 1955. U. of Penn. Museum

One-day Meeting on "Fluid Flow in Practice."

FOR FURTHER INFORMATION CONTACT: E. R. Westfield, Houdry Process Corp., Marcus Hook, Pa.

■ COLUMBUS, OHIO

April 29, 1955. Hotel Deshler-Hilton

One-day Symposium on Industrial Gases, sponsored by five Sections.

FOR INFORMATION CONTACT: R. B. Filbert, Jr., Battelle Memorial Institute, Columbus 1, Ohio.

■ NEWARK, NEW JERSEY

May 10, 1955. Hotel Essex.

Sixth Annual Chemical Engineering Symposium of New Jersey Section, A.I.Ch.E.

FOR INFORMATION CONTACT: J. N. Whelan, Dupont Co., Parlin, New Jersey.

■ CLEVELAND, OHIO

Dec. 12-16, 1955. Cleveland Auditorium.

EJC Nuclear Eng. & Science Congress

PROGRAM CHAIRMAN (A.I.Ch.E.): W. K. Woods, General Electric Co., Richland, Wash.

PHILADELPHIA-WILMINGTON ONE-DAY MEETING PROGRAM

The third annual one-day meeting of the Philadelphia-Wilmington Sections will be held April 26 at the University of Pennsylvania Museum, 34th & Spruce Sts., Phila. Registration will begin at 8:30 A.M.

PROGRAM—"FLUID FLOW IN PRACTICE"

REVIEW OF BASIC RELATIONSHIPS, W. E. Ranz, Penn. State U.

PLANNING NEW PIPING SYSTEMS, S. A. Gertz, M. W. Kellogg

WHICH VALVE & WHY, O. Kneisel, Hammel-Dahl

WHICH PUMP & WHY, C. J. B. Mitchell, DuPont

WHICH FLOW METER & WHY, L. Gess, Minneapolis-Honeywell

OPERATION & MAINTENANCE OF FLUID FLOW EQUIPMENT, N. H. Walton, Atlantic Refining

RESEARCH IN FLUID FLOW, A. S. Foust, Lehigh U.

NEW JERSEY ONE-DAY MEETING PROGRAM

The sixth annual one-day meeting of the New Jersey Section will be held May 10th at Hotel Essex, Newark, N. J. Registration fee is $3 for members and $4 for non-members. Luncheon is $3.

PROGRAM

MORNING SESSION NO. 1

ION EXCHANGE; D. W. Wood, Pres.

ION EXCHANGE, A NEW UNIT OPERATION; R. Kunin, Rohm & Haas.

ION EXCHANGE IN THE PHARMACEUTICAL INDUSTRY; J. Gillin, Merck.

NEW DEVELOPMENTS IN ION EXCHANGE; R. Wheaton, Dow.

MORNING SESSION NO. 2

NEW APPLICATIONS OF CHEMICAL ENGINEERING; R. D. Toomey, Pres.

BIOENGINEERING; E. L. Gaden, Jr., Columbia U.

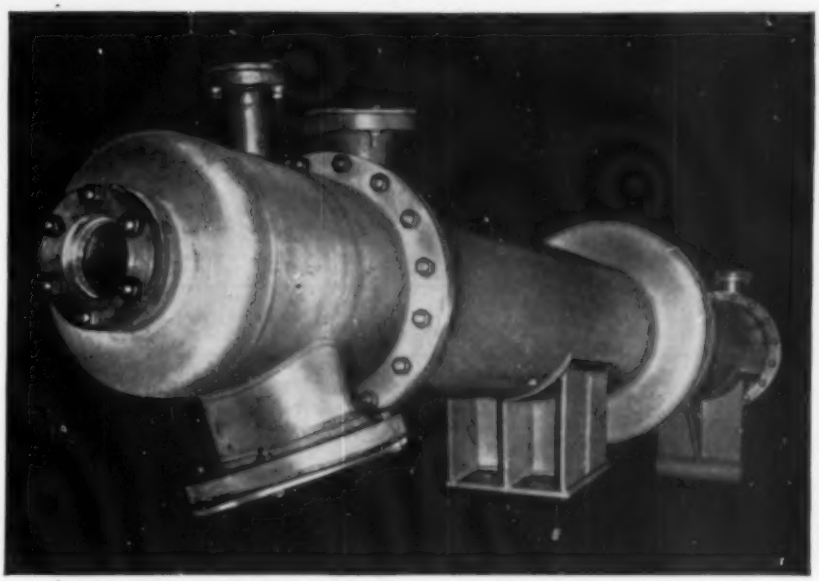
PROPULSION ENGINEERING; L. R. Rapp, Reaction Motors.

NUCLEAR ENGINEERING; T. B. Drew, Columbia U.

AFTERNOON SESSION

CONTROL OF INDUSTRIAL STREAM POLLUTION; H. P. Pursell, Jr., Pres.

PANEL DISCUSSION. Moderator: R. D. Hoak, Mellon Institute. **Legal aspects:** C. Geuther, DuPont. **Biological aspects:** H. Heukelekian, Rutgers U. **Chemical engineering aspects:** J. Morris, Merck.



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6"	37	30	28	31	24	20	14	14	12
8"	68	66	60	55	48	40	31	26	24
10"	110	106	96	85	76	72	42	40	36
12"	170	156	148	126	118	104	64	64	60
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PEOPLE

(*Continued from page* 85)

CHEM E'S ENTER PRIVATE NUCLEAR FIELD

Lawrence C. Widdoes returns to Monsanto Chemical Company to take charge of the design of a large reactor for the production of fissionable material and power after a leave of absence during which he served as project engineer at the U. of Michigan in the design of a nuclear reactor soon to be constructed there.

At the same time news is received that **E. B. Gunyou** has joined Koppers Company to assist in exploring the company's activities in the nuclear energy field. Dr. Gunyou is equipped with wide experience in research and development attendant to nuclear energy.

Monsanto Chemical Company names **Ralph J. Holtschlag** superintendent of all organic chemical division operations at the Seattle plant. **Robert E. Soden** succeeds Mr. Holtschlag as superintendent of technical services in St. Louis.

Henry Groppe appointed assistant director of research and development in plastics division of the company. He is an author of a C.E.P. article on chemical industry expansion.

John E. Bagley appointed development engineer in experimental engineering section of American Viscose Corp. **David M. Ebert** transferred to experimental spinning group of the company. Both men in research and development division.

Esso Labs, Baton Rouge, announce **R. W. Krebs** as associate director and **R. E. Wood** as acting assistant director.

R. W. Richardson assumes duties as associate manager of refinery liaison with Esso Research and Engineering Co., New York.

George A. Rial assumes duties of staff engineer with the Esso engineering department of Standard Oil Development Company.

General Electric places **John A. Loritsch** as manager of the company's alkyd products plant in the chemical materials department.

Frank L. Giordano takes over as manager of the Sawyer Avenue plant of the O-Cel-O division of General Mills and **Gerald J. Joyce** is named works engineer of this plant.

Standard Oil Development Company has established an office of refinery liaison with **Herbert G. M. Fischer** as manager and **Roger W. Richardson** as associate manager.

PEOPLE

(*Continued from page* 89)

— Meet —

PEOPLE

Cedomir M. Sliepcevich heads school of chemical engineering at U. of Oklahoma having rank of full professor.

Sliepcevich comes to his new position after eight years on the chemical engineering faculty of the U. of Michigan.

Besides his responsibilities in the education field, Sliepcevich is consultant to several oil and chemical companies.

Fred L. Hartley succeeds Claude E. Swift as general manager of research and process for the Union Oil Company of California.

J. B. Willis, assistant to the vice-president in charge of research of Sinclair Refining Company, is appointed chief process engineer for Sinclair Chemical, Inc.

A. E. Staley Manufacturing Co. promotes **Ralph E. C. Fredrickson** to director of development engineering department.

Fred H. Poettmann made engineering supervisor of the research lab of the Ohio Oil Co. in Denver.

Chester Stevens heads new product development and lab research as technical director for Eaton-Dikeman Co .

W. W. Bodle is manager of Chicago district office of J. F. Pritchard & Co. **Paul W. Laughrey** takes over as manager of the process and research department of the company.

Koppers Company names **E. W. Volkmann** manager of the research department, and **C. T. Barker** as manager of the engineering department succeeding C. H. Teller, new production manager, for products division. **C. E. Brown** is production manager in the W. Va. plant.

M. G. Sturrock appointed research associate and group leader of the central staff research department of the company.

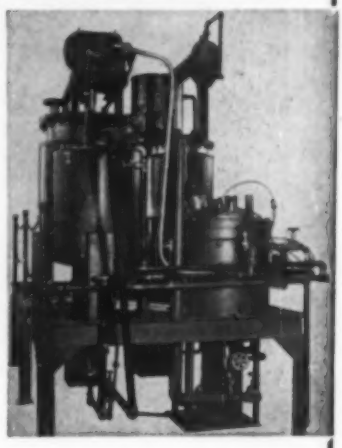
R. W. Pearce takes over the post of works manager of B-I-F Industries, Inc., of Providence, R. I.

Humble Oil & Refining Company promotes six chemical engineers in technical and research divisions: **R. M. Love** to section head; **E. R. Gurtler** as technical specialist; and **D. C. Clark, Bartlett Johnston, J. T. Moody** and **W. K. Roquemore** to senior chemical engineers.

(*Continued on page* 90)

ARTISAN

Pilot Plants and Processing Equipment



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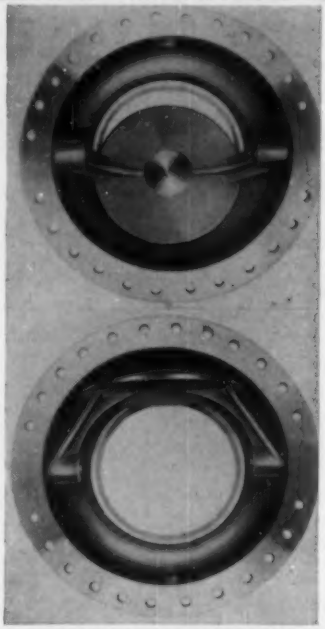

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PEOPLE

(*Continued from page 89*)

Dysart E. Holcomb is elected president of Texas Western College by the U. of Texas Board of Regents.

Dr. Holcomb appears to be the second chemical engineer to become a college president. As a graduate in chemical engineering from Texas Tech, he moved up in 13 years to become dean of the division of engineering of this school.

He has been active in affairs of the A.I.Ch.E. serving in various capacities including membership on the program committee, 1954 symposium chairman and as representative of the Institute on ECPD.

Standard Oil (Indiana) names four to staff of Whiting Research labs: **Charles B. Dale,** Ph.D. in June from U. of Michigan; **Donald H. Ernest,** B.Ch.E. from Marquette; **George W. Falk,** M.Ch.E. from Illinois Institute of Tech., and **Charles J. Billerbeck,** M.S. in chemical engineering from M.I.T.

Donald L. Blanke joins staff of the company at Sugar Creek Lab.

Charles W. Bowman, chemical engineering graduate from Lehigh U. joins Davison Chemical Co. division of W. R. Grace & Co. in research and development.

Chas. Pfizer & Co. names **Stanley W. Ensminger** European manager of production for Pfizer Corp., overseas affiliate.

Conway C. Burton, new chemical engineering grad, joins Chicago Testing Laboratory, Inc.

Harold R. Suter is new vice-president in charge of research and development for Catalytic Combustion Corp.

Foster D. Snell, Inc., announces **N. R. Kuloor** as trainee chemical engineer from India under auspices of Foreign Operations Administration and U. S. Dept. of Labor's Bureau of Apprenticeship.

Paul G. Briggs is new plant supervisor for Atlas Powder Co.'s Memphis, Tenn., plant.

Chemical engineer **Paul S. Aex** named assistant manager of Kodak processing lab, Palo Alto, Calif.

Robert S. Mathews appointed manager of newly-formed vinyl plasticizer department of Archer-Daniels-Midland Co., Minneapolis.

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Necrology

Chemical Engineering Progress recently was notified of the death of the following members:

Allan P. Colburn, 50, provost of the University of Delaware and professor of chemical engineering.

After earning a doctorate degree in chemical engineering from the University of Wisconsin in 1929, Colburn joined E. I. duPont de Nemours in research until 1938 when he began his teaching career at the University of Delaware.

Colburn served as director and chairman of the awards committee and chairman of the publications committee of the A.I.Ch.E. He was a director of the Institute from 1945 to 1947 and was once recipient of the Walker award. In 1948, Colburn was honored as the first to be presented with the professional progress award in chemical engineering.

Leo Christensen, 56, experiment chemical engineer.

Christensen had been associated with chemurgic experiments in Iowa and Nebraska for many years and had become widely known in his field.

His various enterprises included four years as head of a chemurgical project at the University of Nebraska, executive director of the Omaha Industrial Foundation as well as experimenter with and developer of alcohol as a fuel and other experimental work with plants in his fields of interest.

MARKETERS

(*Continued from page* 84)

Reginald Robinson is assigned as West Coast sales representative of Chas. Pfizer & Co.

Edwin M. Ott will direct the sale of all alkalies handled by the industrial chemicals division of the Pennsylvania Salt Manufacturing Company in his new position of product manager.

Celanese Corporation of America announces the appointments of **Edward F. Swanezy** as sales manager of the Chicago district and **M. Henry Jamison** as sales manager in St. Louis. Both men are connected with the chemical division of the company.

With knowledge and experience in electronic and automatic control instruments, **Alden H. Webber** takes over as field sales engineer for the Seattle area of the Bristol Company of Waterbury, Conn.

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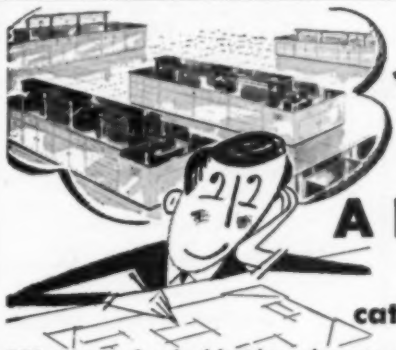

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Job functions include plant and laboratory corrosion tests of metals, protective coatings and cathodic protection equipment; assistance in development of specifications for corrosion resistant materials of construction, cathodic protection equipment, etc.; staff assistance to engineering, operations and maintenance personnel.

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CHEMICAL ENGINEER—Experienced in process control, research, and development. Eleven years in inorganic chemical production, seven years in graphic arts field. Desire employment utilizing experience. Presently in Philadelphia, but location secondary. Box 11-3.

CHEMICAL ENGINEER—Management of process development, design, evaluation. Fifteen years in these and related activities in inorganic and organic chemical manufacture and petroleum processing. Professional engineer, B.S., publications, development of design methods. Far West preferred. Box 12-3.

(Continued on page 94)

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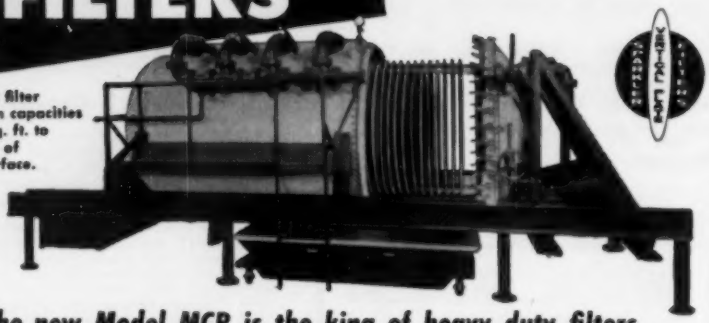

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CHEMICAL ENGINEER—M.S. 1953. Six years' experience in research, development, and pilot plant operations. Desire position in production or technical service in chemical or petroleum field. Age 28. Prefer West Coast location. Box 19-3.

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CHEMICAL ENGINEER—M.S.Ch.E. 1954. Age 27, married, family. Three years' experience in thermal and mechanical design of heat transfer equipment (mainly petroleum) with cost evaluation. Two years' experience production supervision and administration. Process design or development preferred. New York area. Box 24-3.

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USE Chemical Engineering Progress.

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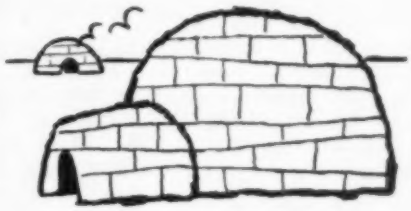

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news and notes

New Engineering Center occupied much of Council's February meeting . . . The Committee of Five Presidents organized last April made its report on February 2 . . . The complete background of the Engineering Center & a summary of the report are given by Past President Kirkbride in an interview on page 24 . . .

Council discussed first the implications of the A.I.Ch.E.'s joining the other four engineering groups . . .Uppermost was whether the Institute could raise the half million dollars necessary to match equities in the new Engineering Center... Council was also convinced of the necessity of creating a new corporation to handle details of the new building since A.I.Ch.E. is not a member of the United Engineering Trust, which has been the group functioning as the real estate group for the other four societies . . .

A resolution was passed concerning our position . . . & is presented in full on page 24 . . .

Paul Kite was asked to continue as chairman of our Housing Committee, which had deferred discussion & meetings until report of the Five Presidents was made . . . Kite's committee's task will be to study for Council the financial implications involved in a move . . .

Another development is that the report of the Five Presidents is not now unanimous . . . D. V. Terrell, past president of the American Society of Civil Engineers, advocates further discussion, as the final report of the Five Presidents ". . . does not present a positive, unqualified recommendation." . . .

There is much more happening . . . Philadelphia has offered the societies six & one-half acres of land plus $1,000,000 or more as may be necessary for building the new headquarters.

The Finance Committee also reported to Council through G. G. Brown . . . One of the important items discussed was the cost of A.I.Ch.E. meetings, which are exceeding registration fees charged . . . There will be a change in meeting accounting practices & the meetings of the future will be asked to support all charges such as preregistration cards, badges, program inserts, a pro-rata program cost, etc. . . The philosophy is that the A.I.Ch.E., out of dues, should be responsible only for notifying members of meetings & for announcing the program. Events such as cocktail parties must be self-supporting . . . Other studies of the finances of the Institute are being conducted & further reports will be made to Council at the Louisville meeting . . .

Council also asked J. C. Lawrence, recently appointed chairman of the Standards Committee, to recommend committee members & special subcommittees necessary to formulate standards & codes . . . It also passed a resolution defining the duties of the committee & defining what a standard or code is . . .

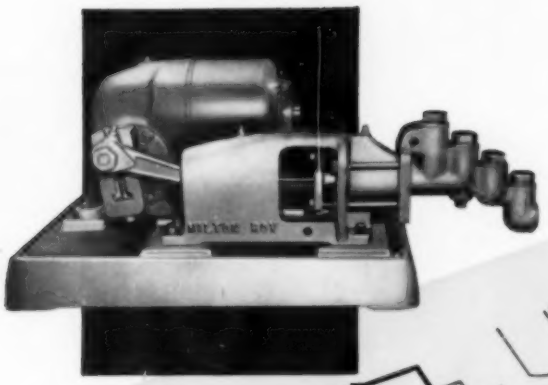
Council approved the membership of the American Society of Refrigerating Engineers & the American Institute of Industrial Engineers in E.J.C. . . Applications for admission to E.J.C. are passed on by the council of each constituent society. . . .

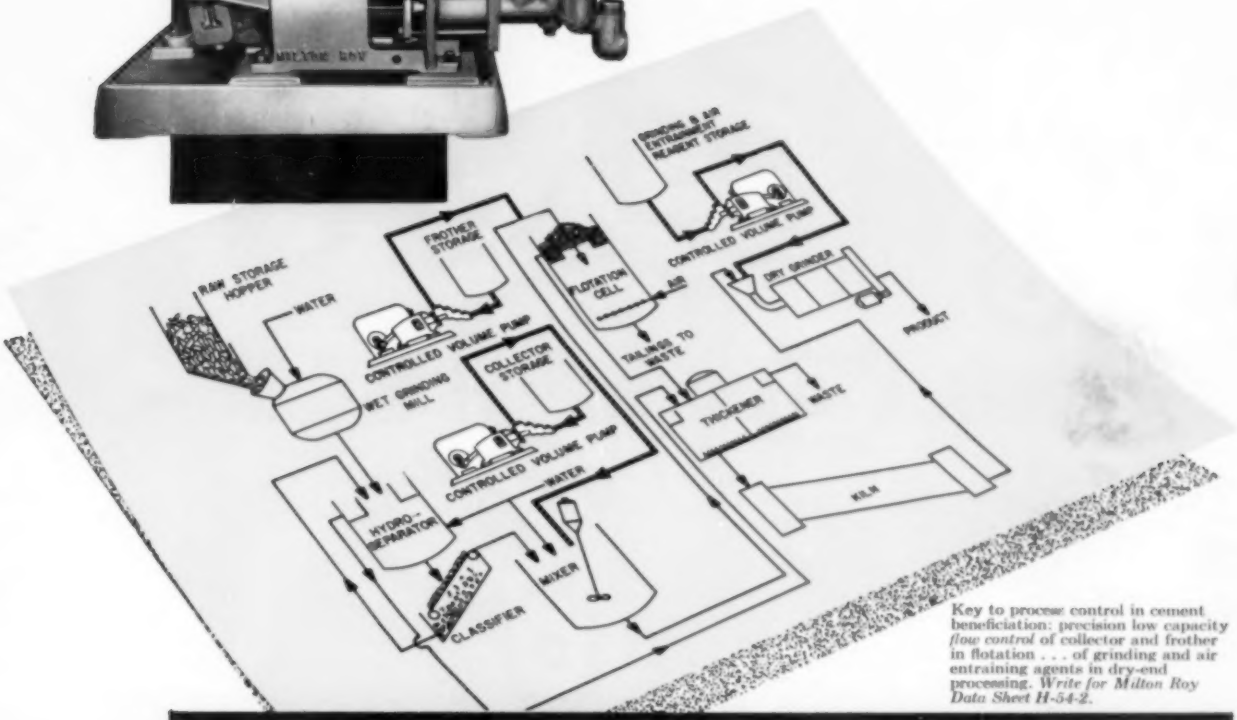
Allan Colburn's death was noted & a resolution of loss & sorrow was passed to be transmitted to the family . . . Allan Colburn was the first recipient of both the William H. Walker & the Professional Progress Awards & also contributed much to the fields of heat transfer, absorption & distillation . . . His friends will be interested to know that a Colburn Memorial Fund is being set up at the University of Delaware to be used for scholarships and to further the development of the research area in which Dr. Colburn worked . . . Those who wish to make contributions to the fund may send them to John P. Cann, Secretary-Treasurer of the University, 814 Industrial Trust Building, Wilmington, Delaware . . .

New Annual Meeting . . . Cincinnati, December 7-11, 1958 . . . Netherlands Plaza as headquarters . . .

Prospective authors should send all manuscripts to headquarters here in New York . . . A central manuscript desk is being maintained so that all papers submitted may be considered for C.E.P., A.I.Ch.E. Journal, or Symposium Series.

F.J.V.A.





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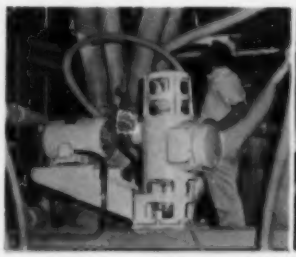

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